THE ENGINEER

A Seven-Day Journal

British Atomic Weapon Test in Australia

A STATEMENT issued from 10, Downing Street last Sunday evening announced that, in the course of the present year, the Government of the United Kingdom intends to test an atomic weapon produced in this country. In close co-operation with the Government of Australia, this test is to take place at a site in Australia. The statement added that this test would be conducted in conditions which would ensure that there would be no danger whatever from radio-activity to the health of people or animals in the Commonwealth.

The Safeguarding of Milling Machines

IN 1945 the Chief Inspector of Factories set up a committee to examine and report upon safety in the use of milling machines in the engineering and allied industries. This committee published an interim report in 1947, and there has now been issued a second report covering investigations which were continued into practical methods of safeguarding milling machines not specially dealt with in the interim publication. This second report makes suggestions and recommendations for special-purpose and other milling machines which present greater difficulties in safeguarding than those used principally for repetition work. It is intended for use in conjunction with the interim report, the two publications continuing recommended methods of safeguarding practically all kinds of machines. The report points out that, in common with other machine tools, the problems of safeguarding milling machines undergo continual changes, as the machine is developed to meet new applications and increase productive capacity. Examples of such developments quoted are the use of electric, pneumatic and hydraulic power for effecting various functional motions, which may introduce hazards other than those due to the cutters alone. To assess the degree of danger associated with various makes and kinds of machines the committee visited a number of selected works, where guards and other safety precautions were examined. The recommendations put forward in the report are designed to make a choice available of appropriate and suitable safeguards for any particular or unusual type of milling machine. It also makes recommendations with regard to the electrical equipment, swarf collection and the lighting of machines, as well as the training and supervision of operatives.

Chief Engineer of Armament Design

THE Ministry of Supply has announced the appointment of Mr. A. P. Wickens as Chief Engineer, Armament Design. At present he is deputy chief engineer at the Fighting Vehicles Design Establishment, Chertsey. Mr. Wickens, who is forty-four, was born and educated at Wolverhampton. After completing his apprenticeship he spent sixteen years with the Nuffield Group, his first experience of armaments being gained with the tank design section of Nuffield Mechanisations, Ltd., which he joined in 1936. Mr. Wickens remained with the Nuffield organisation until October, 1945, when, at the request of the Ministry of Supply, he joined the tank designs section of the Fighting Vehicles Design Establishment, being appointed subsequently deputy chief engineer on tanks. In 1950 he became deputy chief engineer in the wheeled vehicles section of the Fighting Vehicles Design Establishment. Mr. Wickens is a member of the Institution of Mechanical Engineers. The post of Chief Engineer, Armament Design, was formerly held by Mr. S. S. C. Mitchell, whose appointment as Controller of Guided Weapons and Electronics in the Ministry of Supply was announced last November.

The James Clayton Prize

THE Institution of Mechanical Engineers has awarded the James Clayton Prize for 1951, amounting to £1550, to Dr. H. Roxbee Cox, M.I.Mech.E., for his contributions to engineering science and practice, particularly in the fields of aeronautics, power generation and utilisation. The Thomas Hawksley Lecture, which Dr. Roxbee Cox delivered before the Institution last November, was entitled "Some Fuel and Power Projects." It surveyed the research and development work of the Ministry of Fuel and Power and described the ways in which different kinds of coal-burning gas turbines are being developed. Dr. Roxbee Cox has been Chief Scientist of the Ministry of Fuel and Power since 1948. He is a past-president of the Royal Aeronautical Society, and for many years was engaged in aeronautical research work. The James Clayton Prize was presented to Dr. Roxbee Cox by the president of the Institution, Mr. A. C. Hartley, at a general meeting in London last Friday. The prize is derived from a fund established by the late Mr. James Clayton, M.I.Mech.E., who was chief engineer of Courtaulds Ltd. It is awarded annually to a member, associate member, graduate or student of the Institution of Mechanical Engineers, who, in the Council's opinion, has contributed most in the year to modern mechanical engineering science by way of research invention or experimental work, or, by a treatise or paper on a modern mechanical engineering subject, or by originality in design or service to mechanical engineering. The first award was made in 1945 to Sir Frank Whittle for his work in the development of jet propulsion. It is particularly interesting to recall now that Dr. Roxbee Cox worked in association with Sir Frank during the war.

Iraq Oil Agreement

THE friendly negotiations, begun in 1950, between the Iraq Government and the group of companies represented by the Iraq Petroleum Company, comprising British, Dutch, French and American interests, reached agreement in principle in August, 1951. Since then the full agreement has been prepared and the final document was signed on February 3rd, by His Excellency Abdul Majid Mahaud, Minister of Economics, on behalf of the Iraq Government, and by Mr. H. S. Gibson, C.B.E., the managing director of the Iraq, Mosul and Basrah Petroleum Companies. On February 14th the agreement was approved by the Iraq Chamber of Deputies and ratified by the Senate three days later. The terms of the agreement, which are retroactive from January 1, 1951, embody the principle of equal sharing of the profits accruing from the production and export of crude oil from Iraq. Ruling prices and costs will directly control the amount to be shared; but, based on current estimates, it is expected that the Iraq Government will receive in revenue £31,000,000 in 1952, increasing to £60,000,000 in 1955. Of the revenue received from this source, the Government intend to allocate about 70 per cent to finance the schemes of the Iraq Development Board and they include flood control and irrigation projects, schools, hospitals, all of which are intended to raise the standard of living of the people of Iraq. The minimum income of the Iraq Government is agreed at 25 per cent of the seaboard value of all crude oil exported by the Iraq and Mosul Petroleum Companies, plus 33⅓ per cent of the value of that exported by the Basrah Petroleum Company. Other safeguards of the Government's income include a guarantee, under special circumstances, of a payment of not less than £20,000,000 in 1953 and 1954 and £25,000,000 in 1955, and thereafter, and also a minimum of £5,000,000 annually for two years in the event of production of oil from Iraq being precluded by circumstances beyond the control of the companies.

Siting of Radio Direction Finding Stations

THE siting of direction finding stations forms the subject of a radio research report (No. 22), published by H.M. Stationery Office on behalf of the Department of Scientific and Industrial Research. The aim of the report is to examine the causes of direction finding inaccuracies resulting from site conditions, and to give practical guidance on the choice of sites. Many radio direction finders now available have an error of less than 1 deg. and the accuracy of bearings is limited only by imperfections of the station sites, even the best available in agricultural terrain of the kind found in this country. Care is therefore necessary in the choice of sites if full use is to be made of the potential accuracy of a direction finder. Hitherto information on the effects of various site imperfections, such as trees, buildings, hills and other sources of interference, has been scattered throughout the literature of the subject; this report presents information in a single publication. The instruments considered are mainly those with loop or Adcock aerial systems and the frequency range covered, 100 kc/s to 300 Mc/s, is that in which such systems are commonly used. Poor sites in built-up areas or on ships are excluded and the report deals only with normally acceptable sites. No precise definition of a suitable site is attempted and the imperfections studied are those which would be undesirable within a quarter of a mile of the equipment and whose effects might still be significant at a distance of one mile. The report reviews the effects of natural and man-made objects and, wherever possible, quantitative results of tests or operational experience are quoted. But this cannot always be done owing to unpredictable variations between sites and sometimes between results obtained at the same site under varying conditions which cannot always be forecast. The report discusses the limitations on the choice of site imposed by the need for calibration to allow for instrumental errors, since special attention must be given to the calibration of direction finders, particularly those with fixed Adcock aerial systems. Allowance for site errors by means of corrections derived from observations on a local transmitter is possible very rarely, notably when errors are caused by objects close to the direction finder. The main conclusions of the report are summarised in tables showing the minimum tolerable distances for different objects when specified accuracies are required. One table refers to good sites on which accuracies of ½ deg. at v.h.f. and 2 deg. at lower frequencies may be achieved. A second table refers to inferior sites where the corresponding figures are about 2 deg. and 5 deg.

Links in the History of the Locomotive

TREVITHICK'S FIRST RAILWAY LOCOMOTIVE, COALBROOKDALE, 1802–3

By E. A. FORWARD, M.I.Mech.E.

It has generally been thought that the engine made at Penydarran Ironworks, Merthyr Tydfil in 1803–4 was the first Trevithick engine built. Actually, Trevithick first mentioned a locomotive in a letter from Coalbrookdale Ironworks in 1802, saying that the company had begun a carriage at their own cost. The author of this article identifies this engine with the drawing brought to light by W. Llewellyn in 1855 and now in the Science Museum.

MUCH has been written during the past century about Richard Trevithick's railway locomotives, and it has generally been thought that the engine made at the Penydarran Ironworks, Merthyr Tydfil, in 1803–4, was the first one built. Erroneous conclusions were drawn from the known evidence, because Trevithick's own account of his work, contained in his correspondence with Davies Giddy, was not made available until Francis Trevithick published it in the life of his father, in 1872.

Actually, Trevithick's first mention of a railway locomotive occurred in a letter to Giddy, from Coalbrookdale Ironworks, on August 22, 1802. This letter, after describing the testing of a high-pressure stationary engine made for him at that works, ends with a postcript: "The Dale Company have begun a carrage at their own cost for the 'realroads,' and is forcing it with all expedition."

The Coalbrookdale works was evidently the first establishment to take up the manufacture of Trevithick's high-pressure stationary steam engines, after he had secured his patent of March 24, 1802, and the engine tested, in August, 1802, was probably the first one they had made. Trevithick tells us nothing further about this Coalbrookdale locomotive, unless a remark in a letter of May 2, 1803—"There has been no further trial at the Dale"—refers to it. In view of this omission, it has hitherto been assumed that the Dale engine was never completed, but it should be noted that Trevithick similarly made only a single mention of the Newcastle locomotive—in a letter of January 10, 1805—although it is known that such a locomotive was completed and on trial in May, 1805, or seven months after the date on its reputed original drawing.

In recent years, however, evidence has been accumulating, which, when pieced together, tends to show that the Coalbrookdale locomotive was actually completed in 1803, and that it can be almost certainly identified with the, hitherto mysterious, drawing brought to light by Mr. Wm. Llewellyn in 1855, and now in the Science Museum. This drawing was, at that time, thought to represent the Penydarran engine of 1804, although its dimensions should have shown that it could have had no connection with the latter.

Some new light was cast on the Coalbrookdale locomotive in John Randall's *History of Madeley*, published in 1880, but only recently seen by the writer. From this it appears certain that the engine was, in fact, finished, tried and subsequently broken up at the works. In his book, Randall records the reminiscences of W. A. Reynolds, a nephew of William Reynolds, of Coalbrookdale, as follows:—

"Trevithick had constructed working models, much resembling modern locomotives in construction, before the year 1800. In 1802, the Coalbrookdale Company were building for him a railway locomotive, the engine of which was tried first in pumping water." After quoting Trevithick's letter of August, 1802, he continues:

"There was a beautifully executed wooden model of this locomotive in my Uncle William Reynolds' possession, which was given me by his widow, the late Mrs. Reynolds of Severn House, after his death. I was then a boy, fond of making model engines of my own, and I broke up this priceless relic to convert it to my own base purpose, an act which I now repent as if it had been a sin."

"The Coalbrookdale engine is, I believe, the first locomotive engine on record intended to be used on a railroad. The boiler of it is now to be seen in use as a water tank at the Lloyd's Crawston Pit, and the fire tubes and a few other portions of it are now in the yard at Madeley Wood Works. I never knew how it came to be disused and broken up"

To take precedence over the Penydarran engine the Coalbrookdale one should have been completed during 1803, and, judging by the time taken to build the Newcastle engine, it might well have been finished by the middle of that year. Trevithick, in March or April, 1803, gave to Simon Goodrich, the Engineer and Mechanist to the Navy Board, some particulars of an engine at Coalbrookdale, with a cylinder 5in diameter and 3ft stroke, which had been tested by pumping water. As he coupled this with particulars of the London coach engine of May, 1803, it is possible that the 5in engine tested was that used in the locomotive.

Trevithick's first mention of the Penydarran locomotive occurred in a letter to Giddy, of October 1, 1803, in which he wrote:

"There will be a 'realroad' engine at work here in a fortnight; it will go on 'reals' not exceeding an elevation of one-fiftieth part of a perpendicular and of considerable length. The cylinder is 8½in diameter, to go about two and a half miles an hour; it is to have the same velocity of the piston-rod. It will weigh, water and all complete, within 5 tons."

In spite of Trevithick's optimistic statement, this locomotive was still incomplete on January 5, 1804, when he wrote to Giddy explaining the delay, and it was not ready for trial until February 11, 1804—that is, four and a half months after its first mention. Presuming, then, that the Coalbrookdale locomotive was completed in 1803, it could undoubtedly claim to be Trevithick's first railway locomotive, but we should still be in the dark as to its construction. Its arrangement and dimensions would, however, depend very much on the form of the railroad, and especially on the gauge of the track, about which features there was no information until recently.

It was known that, from about 1750, wooden railways had been adopted at Coalbrookdale to connect the various works of the company, and are said to have been copied from those used in the North, hence they probably had the then common gauge of 4ft. In 1767, it is recorded that a start was made in laying flat cast iron plates on the wooden rails, and that 800 tons of iron had been so laid up to 1771, while, by 1785, there were some 20 miles of these iron roads. Further, it is said, in the *Victoria History of Shropshire*, on the authority of John Randall, that, at some unknown date, "a narrower gauge of road and a different pattern of rail were introduced."

This change would seem to be connected with Dr. James Anderson's statement of 1801, that John Curr's narrow-gauge, angle-plate rails were much used in Shropshire for surface lines. Curr certainly appears to have had a close connection with Coalbrookdale, as adviser on transport matters, in 1793, and it may be supposed that the change from edge rails to plate rails was made, on his advice, about that time.

The next record we have dates from 1827, in which year two Prussian mining engineers visited Coalbrookdale and recorded that they saw there a tramroad from the lower smelting works to the Severn. On this, the plate rails were laid on transverse cast iron sleepers and formed two tracks with gauges of 36in and 20in, laid one within the other. The same type of track was seen there in 1924, but with only one gauge of 27in.

From these particulars it may be gathered that the Coalbrookdale railroads were converted to the plate rail form before 1802, and that their gauge was somewhat less than 4ft. Assuming that no change of gauge was made between 1802 and 1827, the gauge for which the locomotive was designed would be, almost certainly, the 3ft one.

When Francis Trevithick was gathering

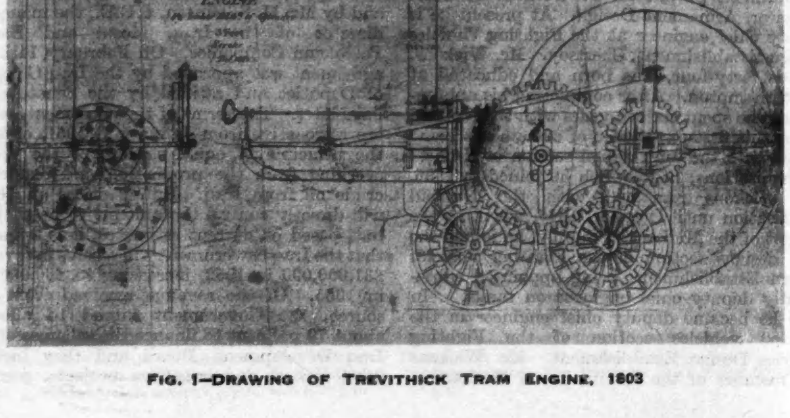


FIG. 1—DRAWING OF TREVITHICK TRAM ENGINE, 1803

information about his father's work, he enlisted the aid of Thomas Ellis, of Tredegar, and William Menelaus, of Dowlais, in seeking particulars of the Penydarran locomotive of 1804. In this connection, Menelaus received, from William Llewellyn, a drawing of a locomotive engine said to represent the Penydarran engine (see Fig. 1). Llewellyn's letter accompanying the drawing is as follows :—

Pontypool, 24th November, 1855.

Dear Sir,

I regret that I should have forgotten to send you the drawing of the old locomotive which you asked me for some time ago. I have had a pretty long search for it, but succeeded in finding it at last. I observe that nothing is mentioned upon it of its being the engine constructed by Trevithick, but inasmuch as I am aware that my uncle was engaged with him at Merthyr on the trial made there on the old Navigation tramway, and have the impression of hearing my uncle say that it was a rough draft of the original engine, I think there is very little doubt upon the subject. It was drawn by uncle (very roughly, as you will see) in the year 1803, which was about the time Trevithick was at Merthyr. You will perhaps be kind enough to get the parties you send the sketch to to return it when done with. I should tell you that I shall send the drawing in another enclosure.

Dear Sir, yours very truly,
William Llewellyn.

N.B.—The cylinder was 4¼ inches diameter and 3 feet stroke.

Apparently this drawing was not returned to Wm. Llewellyn, but was given by Menelaus to Mr. Bennett Woodcroft, in 1862, for exhibition in the Museum of Patents, from whence it descended to the Science Museum.

Engineering for March 27, 1868, refers to it as follows :—

"The drawing of Trevithick's first locomotive is now in the Patent Museum, South Kensington. This drawing was not made, as has been generally supposed, by himself, but by John Llewellyn, a mining agent at Merthyr."

Menelaus confirms this in a letter, written on January 27, 1872, to J. W. Hackworth, in which he said that the drawing was given to him by Wm. Llewellyn, and that he sent it to the South Kensington Museum, at the request of the Managers of that Institution.

It will be seen that Wm. Llewellyn's impression of his uncle's remarks is rather vague, and although he appears to think that his uncle meant that it was a drawing of the Penydarran engine, he might equally well have meant that it was, in fact, a drawing of Trevithick's first railway locomotive—that is, the Coalbrookdale one. In any case, the letter implies that John Llewellyn had made the drawing from an actual and complete engine, but it could have been seen just as well at Coalbrookdale as at Penydarran.

The writer believes that the drawing now in the Science Museum is the original one made by John Llewellyn, in December, 1803, and that it shows the Coalbrookdale engine. It is obviously very old, and is, as Wm. Llewellyn said, very roughly drawn, many of the small details being put in freehand, while one wheel is shown with nineteen spokes and the other with twenty.

Although the Llewellyn drawing was in the writer's charge for over thirty years, and had been studied from time to time, yet, apart from the Llewellyn story, there was nothing to connect it with any particular location, as no tramroad was known with a gauge of 3ft, on which it might have run. During all that time it never occurred to him that the drawing might represent the Coalbrookdale locomotive, because it was so firmly believed that that engine was never completed, and nothing was known about the change of track at Coalbrookdale. When, however, evidence appeared for the 3ft tramroad, and for the completion of the engine, the possibility that the drawing represented the Coalbrookdale locomotive at once became apparent.

It seems strange that Thos. Ellis and Wm. Menelaus accepted the Llewellyn drawing as representing the Penydarran locomotive, as it must have been within their personal knowledge that the Merthyr–Navigation tramroad had a gauge of 4ft 2in, and not 3ft as shown on that drawing. They also appear to have accepted the cylinder dimensions of 4¼in diameter by 3ft stroke as being those of the Welsh engine. We must assume, therefore, that they knew nothing of the existence of the Coalbrookdale engine at that time, nor of the larger dimensions of the Penydarran engine given by Trevithick. Their argument must have been that, as they knew of one engine and one drawing of a reputed Trevithick engine, of about the same date, then the two must be connected.

It now seems to the writer that he, by a similar argument, might have identified the Llewellyn drawing earlier. After Trevithick's letters had been revealed, we had a knowledge of three locomotives and one drawing, but as two of these engines were obviously much larger than the one in the drawing, then it could be argued that the latter, in all probability, represented the third, or Coalbrookdale, engine, about which nothing else was known.

Having seen that the Llewellyn drawing really represents the Coalbrookdale engine, it merits somewhat close study in order to discover reasons for the peculiar features wherein it differs from Trevithick's Newcastle locomotive, of 1805, and from his contemporary stationary engines. It may be supposed that the basic design was Trevithick's, but he probably left much of the detail to be worked out by the Coalbrookdale engineers.

The drawing is entitled "Tram Engine, 4¼ inches Diam. of Cylinder, 3 feet Stroke. Decr. 1803." From the cylinder dimensions given, the scale of the [original] drawing is 1in to 1ft, at which scale the gauge of the rails (not shown) would be 3ft between the backs of the flanges, the wheel diameter also being 3ft.

The boiler was a flanged cast iron cylinder, with flat ends bolted on, and formed the foundation of the whole engine. With a track gauge of only 3ft and with the wheels closely spaced, as shown, it would be impossible to have a boiler barrel more than 3ft external diameter, while, at the same time, the flanges by which the ends were attached must be cut off at the sides to the same width. This meant that the boiler barrel must have internal flanges at those points, to make a sound joint all round, and tapped bolts must be used there instead of through bolts and nuts, just as shown on the drawing. These inner flanges would reduce the clear inside width of the boiler ends to 30in. The boiler was 4ft long over the flanges, and the front end plate was provided with flanged necks to which the fire-door and chimney base were bolted. The fire-grate could not exceed 14in in width, so that a length of 42in would be required to give a grate area of about 4 square feet, such as Trevithick obtained in his London coach engine of 1803. As this would occupy nearly the whole length of the boiler, they could not put in a bent return flue tube like that in the Newcastle engine, nor like the double return flue of the coach boiler, hence they solved the problem by putting in two parallel tubes of 15in and 7in external diameters, running right through the boiler, and connected at the back end by an external smokebox. These tubes were riveted to the external necks cast round the openings in the end plates. Owing to the presence of these tubes, the cylinder could not be placed vertically, as in Trevithick's most usual stationary engine practice, so that it had to lie horizontally near the top of the boiler. This rather cramped the positions of the flue tubes, as the large flange by which the cylinder was fastened to the end plate interfered with the neck of the fire-tube, which had to be made long enough to enable its flange to clear the cylinder flange and its bolts. The two tubes lay close together to allow for satisfactory riveting to the necks, and the small tube came very close to the boiler shell. The fire-tube had to be placed as low as possible, but, even so, the large cylinder flange had to be cut away at one point to clear the fire-door neck.

In the Newcastle engine, the cylinder flange, by which it was attached to the boiler, was set eccentrically to the cylinder axis on account of the steam port running along the top of the cylinder, and so could be of minimum diameter, but the Coalbrookdale one was concentric with the cylinder axis, thus requiring a relatively larger flange and a lower position for the axis. This feature suggests that the cylinder was designed for use in a vertical, pot-boiler, stationary engine in which the cylinder and boiler axies coincided. The cylinder diameter of 4¼in probably arose from the use of a 5in cylinder casting which bored clean a little under size, and we have seen that engines with 5in cylinders were then being made at Coalbrookdale.

The large cylinder flange also prevented the cylinder head from being placed at the back end of the boiler, as was done in the Newcastle engine, because that flange would have fouled the smokebox; hence, the cylinder head had to be put at the fireplace end, making it very awkward, if not impossible, to fire the boiler when the engine was running. This defect was avoided in the Newcastle engine, and probably in the Penydarran one also, because their boilers were large enough to contain an internal return flue, and so permitted the cylinder head to be at the opposite end to the fire.

The regulating and throttle cocks are rather vaguely indicated on the drawing and appear to differ in their arrangement from other known forms. The regulating cock was moved by a tappet rod operated by a bar on the crosshead. This bar struck the tappets near the end of each stroke so as to rotate the cock through 90 deg. A handle was provided on the end of the tappet rod by which the cock could be set for starting. The connection between the tappet rod and the cock is not visible, but, in the end view, a valve box is roughly pencilled in and the rod is placed on the cylinder and boiler centre line. This suggests that the cock may have been offset, and was perhaps rotated by a rack and pinion, instead of by a simple lever as in later practice, because the motion of the tappet rod would be closely limited by the proximity of the cylinder flange. This cock-working arrangement is the reverse of that usually adopted where the tappet rod was attached to the crosshead and struck a lever on the cock, but the latter lay-out required a clearance space for the rod to work through the full piston stroke. It is possible that the Coalbrookdale engine had a separate cock block containing the two cocks, this being set in a recess cast in the cylinder, like that shown in one of the Newcastle engine drawings. No means are

shown for moving the throttle cock. In Trevithick's patent of 1802, the regulating cock was rotated intermittently, through 90 deg. at a time, by a cam on the crankshaft, through levers and a ratchet clutch.

A special point about these cocks is that they are shown with screws bearing on their heads to prevent them from being blown out of their seats. These screws are rarely seen on drawings of Trevithick engines, but they appear on all the surviving engines known to us. Their presence on this drawing may be taken to indicate that the draughtsman was putting in something he actually saw, just as when he discriminated between the tapped and the through bolts for the boiler ends.

The engine wheels are 3ft diameter and 1in wide on the tread; they run loose on the ends of fixed axles bolted to the boiler, as was the common practice with wagon wheels running on plateways. The two wheels on one side of the engine carried spur wheels with twenty teeth, which were connected by a wheel with thirty-six teeth, turning on a pin fixed on the side of the boiler. This large wheel was engaged by a twenty-tooth wheel mounted on the crankshaft, which revolved in bearings bolted to the back end of the boiler, above the smokebox. The drive was thus applied to the two wheels on one side, so that only about one-half of the engine weight was available for adhesion. The wheel teeth shown are very coarse, their pitch being nearly 3·5in.

The chimney was of wrought iron, 8in diameter, mounted on a cast iron elbow bolted to the neck of the smaller flue tube. Its height was 8ft 7in above the rails. A flywheel was mounted on the crankshaft, but no provision was made for disconnecting the crankshaft from the running wheels, as was done by a clutch in the Newcastle engine. When starting, the engine would have to be pinched along until the cranks were at right angles to the connecting-rods. The crosshead was guided by round bars attached to the cylinder head at one end, and supported at the outer end by a pair of cantilever brackets bolted to the boiler.

It does not appear to have been realised at first that the inertia of the moving parts of a locomotive, when running, rendered a flywheel unnecessary; it would only be needed if the engine was required to work as a stationary one, at times, as was definitely the case with the Penydarran locomotive. There is no sign of an exhaust pipe in the Llewellyn drawing and, although perhaps masked by the valve box in the side view, it should, if present, have been visible in the end view. It is definitely known that the exhaust steam was discharged upwards in the chimney of the Penydarran engine, in February, 1804, but the first pictorial record of it appeared in the sketch of the London coach engine given by Trevithick to Simon Goodrich in April, 1803. In Trevithick's patent of 1802 the exhaust steam was passed into the feed water, or round the boiler casing, the only means suggested for exciting the fire being a bellows worked by the engine. No safety valve can be seen on the boiler.

It would appear from the correspondence published by Francis Trevithick in 1872 that Thos. Ellis had found it impossible to get any satisfactory idea of the Penydarran engine by the interrogation of the old men who were supposed to have worked on it, and had seized upon the Llewellyn drawing as an easy way out of the difficulty, in spite of the rail gauge discrepancy. Ellis, in 1857, under the auspices of the *Mining Journal*, published a drawing purporting to represent the Penydarran locomotive, but that drawing was obviously a copy of the Llewellyn drawing, tidied up and slightly altered in parts, but possessing all the special features which, as has been shown, were entirely due to the 3ft gauge of the Coalbrookdale tramroad. These features would not have been necessary on the Penydarran tramroad with its 4ft 2in gauge. But Ellis, in his drawing, left out Llewellyn's dimensions and the end elevation.

Francis Trevithick was undoubtedly misled by Ellis's drawing, which he adopted as the basis of his own reconstruction of the Penydarran locomotive, but he multiplied the dimensions of the Llewellyn drawing by about one and a half, so as to make the piston stroke 4ft 6in, while, at the same time, he made the rail gauge 4ft instead of 4ft 2in. He made, also, sundry other alterations, particularly by putting into the boiler an internal return flue, but at the same time retaining the external smokebox belonging to the Coalbrookdale engine. Francis Trevithick did not illustrate the original drawing in his book. All other attempted reconstructions of the Penydarran locomotive had been based on the Coalbrookdale drawing, or on Ellis's version of it; but all such designs are now known to be incorrect, because not one of them would have passed through the tunnel on the Merthyr tramroad behind the Plymouth Ironworks, the dimensions of which were shown, by Mr. Stanley Mercer's recent survey, to be 8ft high and 8ft 5in wide.

Having shown that the features of the Coalbrookdale locomotive were special to itself, and can have had little or no influence on the Penydarran engine, it will be seen that the only knowledge we now have of the latter consists mainly of Trevithick's own statements, and John Farey's account written for *Rees' Cyclopedia* in 1816; they give us the principal dimensions, but tell us little about the actual construction.

In the writer's opinion, therefore, we can best be guided by the Newcastle locomotive of 1805, the reputed original drawing of which is dated October 3, 1804, as we might expect Trevithick to have modelled it on the Penydarran one. In addition, we now have a loading gauge in the shape of the Plymouth Works tunnel, the size of which would compel the use of a horizontal cylinder, the removal of the flywheel, the adoption of running wheels not more than 3ft diameter, and the shortening of the chimney. It may be that this short chimney, as well as that of the London coach engine, led to the use of the exhaust steam to excite the fire.

Although the Penydarran locomotive now loses its place as the first railway locomotive, it still has considerable interest as it is the only one of Trevithick's three locomotives of which we have any record of its work. Trevithick himself, when writing to Sir John Sinclair on April 26, 1812, mentions only the Penydarran engine trials, but says they took place about six years ago (i.e., 1806 instead of 1804). This may indicate that he regarded the Coalbrookdale and Newcastle engines as unimportant, or else that he had no record of any useful work performed by them.

Through the kindness of Mrs. E. Reder, of Reading, we are able to publish in connection with Mr. Forward's article a photographic reproduction of an original painting by Philip James de Loutherbourg of "Coalbrookdale by Night," which recently came to light by turning up at an auction at Christie's. Of the picture Mrs. Reder says:—

"Coalbrookdale, near Ketley, acquired a considerable reputation in the eighteenth century as a centre for the smelting of iron. The place profited from the beginnings of the industrial revolution and became quite a showplace, so that artists of repute, in quest of picturesque and curious aspects of life in England, came to see it. Philip James de Loutherbourg was such a one. A well-known painter and engraver, he lived for most of his life in London, where he established himself after working for some time in France. In London, he was for some time scenery designer to Garrick at Drury Lane, and became an R.A. in 1780. Coalbrookdale evidently impressed him for its picturesque and dramatic qualities. The painting he made of the site, and with which we are here concerned, was included in the Royal Academy Exhibition of 1801, in whose catalogue it appears under No. 54. Painted on canvas, and measuring 26¾in by 42in, it shows the foundry enclosed in its dale, vividly illumined by the glare of its furnaces and weakly by the full moon. On a hillock in the left foreground are a few cottages, and on the right a heavy wagon, drawn by cart-horses, advances along a rough road on whose sides lie a few examples of Coalbrookdale's industry. On one of these, a boiler, the painter has affixed his signature—P. J. de Loutherbourg, R.A.—and the date 1801. The colours are, in spite of time, quite vivid, ranging from light red and yellow to greys and browns of varying intensity, and the execution is vigorous and spontaneous."

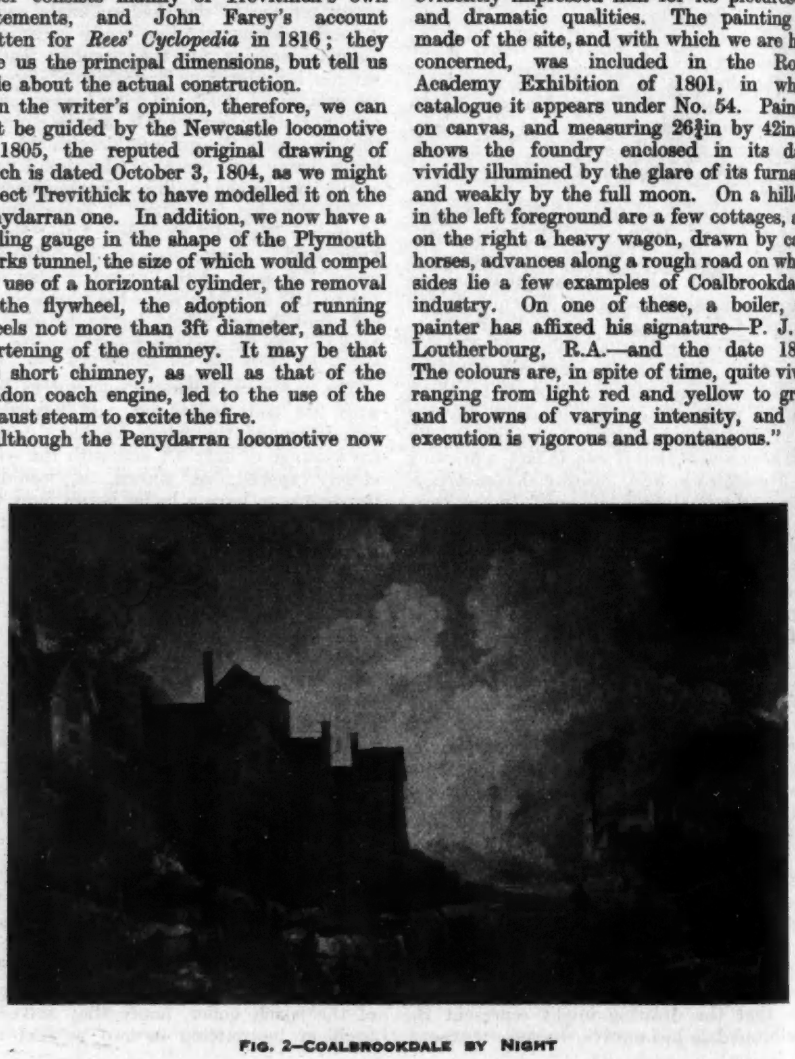


FIG. 2—COALBROOKDALE BY NIGHT

A Coal-Burning Gas Turbine

No. II—*(Concluded from page 254, February 15th)*

The Locomotive Development Committee of Bituminous Coal Research, Incorporated, at Dunkirk, New York, has now completed full-scale test operations for a period of 1000 hours of a Houdry process gas turbine on a direct-fired open cycle, with coal as its primary fuel. Interesting combustion and ash removal equipment has been developed, which is being employed in a locomotive gas turbine test installation now in process of erection at Dunkirk. The work is described in this article.

Blade Erosion

THE first 250 hours of coal-fired operation of the Houdry turbine were completed in March, 1950. The turbine was then opened for inspection and several segments of the first row cylinder blading were found to be eroded. The erosion was most pronounced in the upper half of the casing, between 12 and 2 o'clock. A small portion of the blading was affected between 3 and 4 o'clock and also between 5 and 7 o'clock in the lower half of the casing. In these segments the erosion was confined to a band not more than an inch wide, extending radially outward from the tips of the cylinder blading. The localised nature of the erosion in the first row was unexpected, since this kind of erosion has not been encountered in normal Houdry gas turbine practice. Little if any erosion could be found on the second, third or fourth cylinder rows. The fifth row showed some erosion in a band extending about ¼in inward from the blade roots. In analysing the nature of the erosion it became apparent that the ash which remained in the air after the separator had been concentrated into persistent streams by the forces experienced in passing through the inlet piping. The fly ash separator outlet at Dunkirk is horizontal, while the inlet to the Houdry turbine is vertically downward. A "gooseneck" is provided to make the necessary changes in direction and flexibility is incorporated into this piping through the use of four torroidal bellows.

It was concluded after the first 250 hours of operation that the extremely fine dust which is scattered uniformly throughout the air stream is relatively harmless. The localised nature of the erosion also led to the conclusion that the ash particles responsible for this damage must be quite large and they should therefore be caught in a properly functioning separator. As Fig. 9 shows, the first row blading revealed a pattern of twin notches, which apparently resulted from the presence of a lashing wire. As the dust-laden air flowed over the lashing wire, a vigorous double-eddy was set up in each blade passage, which operated much like a pair of small milling cutters. This action was sufficiently persistent to penetrate across the first moving blade row into the second cylinder row. No damage of any importance was done to the rotor blades during the first 250-hour test. There were a number of nicks on the leading edges of the first blade row, indicating that many large ash fragments had passed through the separator. There was no evidence of any weakening of the rotor blades, however, and no replacement was considered necessary.

During the second 250-hour test more erosion took place and, for the first time, damage was found on the first row of moving blades. The machine began to take on the characteristic appearance of a Houdry turbine, with erosion at the roots of the last row of cylinder blading and thinning of the tips of the rotor blades. The first row of cylinder blades was replaced at 500 hours with a new row from which the lashing wires were omitted. The first rotor row was also replaced. The third 250-hour test caused a serious amount of erosion to take place in the first three rows of cylinder blades, and the last two rows showed much more cutting at the roots of the blades.

The fourth 250-hour test was run with the battery of twelve "Dunlab" tubes, with very encouraging results. Careful inspection of the new cylinder blading at the end of the test showed that only very slight traces of erosion existed. The dust entering the turbine during this period contained few +20 micron particles, and about 85 per cent of the dust was −10 microns. No measurable erosion could be detected on the second and third cylinder rows, and careful inspection was needed to find any eroded spots on the first row. The roots of the fifth cylinder row, which had been cut progressively since the first 250-hour test, showed little if any additional erosion.

From the results of this fourth test it was concluded that, under the operating conditions of the Houdry turbine, the "Dunlab" separator gave adequate protection to the blading. While it is premature to conclude that the ash separation problem has been completely solved, it can be said that the passage of small quantities of +10 micron ash does not appear to result in rapid damage to the cylinder blades.

With regard to the rotor blading of the Houdry unit, the first row had been renewed at the end of 500 hours, but the remaining four rows had been in the turbine during the entire 1000 hours of coal-fired operation. The blading proved to be in excellent condition and the only noticeable change was a slight thinning and sharpening of the blade tips. The "Dunlab" separator apparently prevented the passage of any appreciable number of large ash particles, because the leading edges of the first blade row were found to be virtually free of the nicks which were seen after the first 250 hours

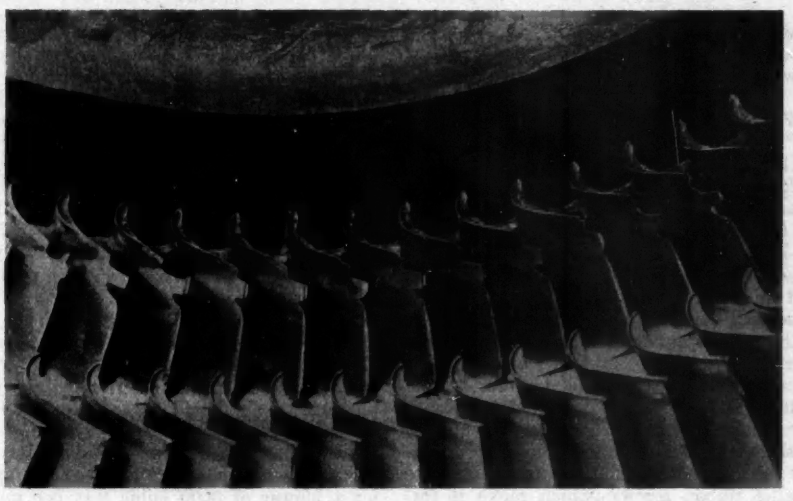


FIG. 9—CYLINDER BLADING AFTER 250 HOURS

Locomotive Gas Turbine Test Installation

The object of the Locomotive Development Committee's programme has always been to produce a coal-burning gas turbine locomotive which could be used to demonstrate the feasibility of such a power plant. After the first year of the programme the committee felt that there was enough hope of success to warrant the purchase of a full scale gas turbine. Contracts were placed with both the Allis Chalmers Manufacturing Company, of Milwaukee, Wisconsin, and the Elliott Company, of Jeannette, Pennsylvania, for the construction of 3750 h.p. locomotive turbine plants with traction generators and all

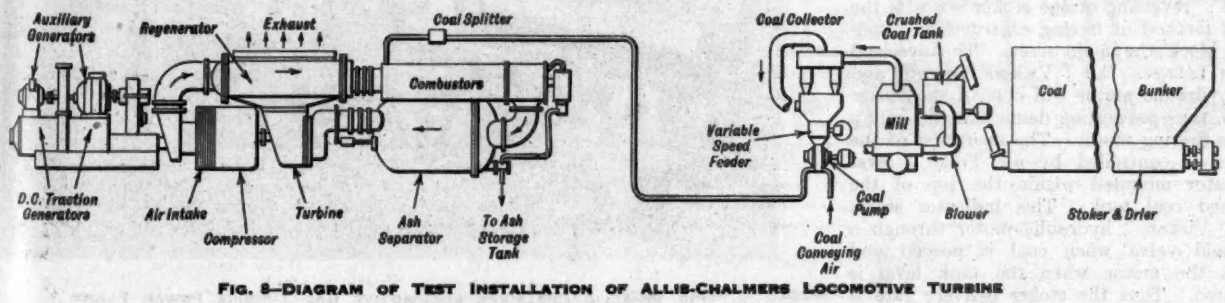


FIG. 8—DIAGRAM OF TEST INSTALLATION OF ALLIS-CHALMERS LOCOMOTIVE TURBINE

necessary control equipment. Construction of the two turbines proceeded in parallel with the development work which has been described in this article. In the autumn of 1950 it was felt that enough experience had been accumulated with the Houdry turbine to justify the belief that the locomotive turbines could safely be operated on pulverised coal. Full capacity coal-handling equipment and a pulveriser were purchased and the erection of a test plant was undertaken by the Alco Products Division of the American Locomotive Company at Dunkirk, New York.

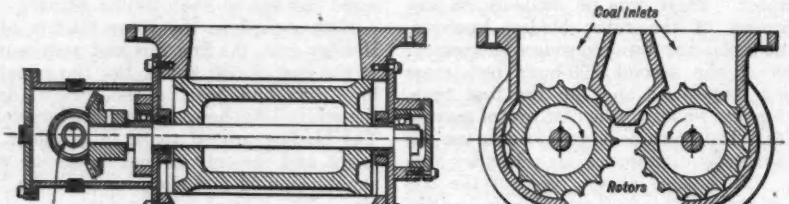


FIG. 10—PULVERISED COAL FEEDER

COAL-HANDLING EQUIPMENT

The coal preparation equipment was designed to fit within the space limitations of a locomotive. The original specifications for the first experimental locomotive called for equipment which could take aboard run-of-mine coal, dry and pulverise it, and feed it, under proper control, to a variable-speed gas turbine. The general principles of the system are similar to those used with considerable success in the Houdry plant. Fig. 8 shows a schematic diagram of the system. Coal is carried towards the rear of the stoker by a two-level screw and is crushed by conventional breaker plates. The crushed coal is then dropped into two parallel ribbon screws, which move it forward through the drying section. Hot air from the turbine exhaust passes at low velocity through the drying section in contra-direction to the coal. Twin elevator screws lift the crushed and dried coal to a storage tank situated between the bunker and the pulveriser.

The stoker is driven by a 25 h.p. induction motor through a "Vickers" variable-speed, reversible, hydraulic transmission. Power for the stoker and all other auxiliary equipment will be supplied by two 175kVA alternators, which are driven by the turbine reduction gear. The frequency of this a.c supply will vary from 66·6 to 40 c/s as the turbine slows down from its full load speed of 5700 r.p.m. to its idling speed of 3420 r.p.m. Thus, the rate of coal delivery will automatically vary from 100 per cent at full turbine speed to 60 per cent at idling speed. The variable speed feature of the "Vickers" transmission allows the stoker delivery rate to be adjusted over a wide range; reversing of the stoker screw is the usual method of freeing obstructions which may block the main screw. The overload valve between the "Vickers" pump and the hydraulic motor will open if the stoker stalls, thus preventing damage to the pump or its driving motor. The operation of the stoker is controlled by a "Fuller" level indicator mounted within the top of the crushed coal tank. This indicator starts the "Vickers" hydraulic motor through a solenoid valve when coal is needed and stops the motor when the tank level is restored. Thus the stoker delivery rate is kept reasonably close to the turbine fuel requirements but sufficient storage (500 lb) is provided so that exact regulation of the stoker is not needed. D.c. is normally supplied by a 25kW generator, which is driven from the reduction gear. A 64V locomotive battery and charger are also provided, so that the few d.c. auxiliaries can be operated and the controls energised when the turbine is shut down. Coal is delivered from the crushed coal storage tank to the pulveriser by a transverse screw, which is driven by a two-speed a.c. motor. This motor will also change speed in proportion to turbine speed, but the mill level controller will start and stop the motor through suitable switch gear.

The pulveriser was manufactured by the Babcock and Wilcox Company of New York, and is a two-row mill, rated to deliver about 4500 lb of 90 per cent —200 mesh coal per hour, having a grindability not lower than 50 Hardgrove. It is driven by a 50 h.p. induction motor, which, like the other auxiliary motors, is started and stopped by push buttons on the coal-handling electrical panel. The mill has a high-pressure casing, which enables direct firing to be tried if the atmospheric system should, at a later date, be replaced by a pressurised system. The pulverised coal is carried from the mill through two discharge pipes by air supplied by a blower of 3000 cubic feet per minute capacity, driven by a 30 h.p. induction motor. The air flow can be regulated by dampers. A recirculating air system is used in which the air, after the coal has been stripped out by the collectors, is returned to the blower intake. Coal delivery to the storage tank is controlled by a second "Fuller" level indicator, which operates a relay in series with the pulveriser level controller. When the pulverised coal level falls below the desired point, the "Fuller" indicator calls for coal. The pulveriser level controller, a standard instrument made by the Bailey Meter Company, of Cleveland, Ohio, then signals the crushed coal feed motor whether the mill needs coal. If the pulverised coal tank is full the mill controller is over-ruled and no coal is supplied until the tank level indicator again calls for coal.

The pulverised coal is fed by a twin-drum "Rotolock" feeder, shown in Fig. 10, which is driven by a d.c. motor through an "Oilgear" hydraulic transmission. The throttle for the turbine is the speed control lever on the "Oilgear" variable displacement pump. The speed control lever is actuated by a "Hagan" pneumatic positioner, which can be operated either manually or automatically. The coal pump, described previously, is driven by a 5 h.p. gear-motor. The pump speed will vary from 100 to 60 r.p.m. as the turbine load changes, but this variation is not expected to cause any difficulties. Shop air will be used to convey the coal from the pump to the coal splitter and the twin combustors. At a later stage a positive-displacement booster blower will be used to take cooled air from the main compressor discharge and raise its pressure sufficiently to overcome the losses in the conveying air system. This booster will be driven by an a.c. motor and the resulting speed variation is expected to give automatic control to the air-coal ratio. A regenerator of approximately 50 per cent effectiveness is used to preheat the compressed air before it enters the combustion system.

GAS TURBINE POWER PLANT

The Allis-Chalmers locomotive gas turbine power plant, shown in Fig. 11, has been erected at Dunkirk within locomotive cab contour limitations. Temporary ductwork is being installed to lead outdoor air from above the building roof through a flow nozzle to the compressor intake. The exhaust will also be discharged through the roof. The six-stage reaction turbine was designed to operate on the open cycle with an initial gas temperature of 1300 deg. Fah. and to deliver 4250 h.p. to the input shaft of the reduction gear. The reduction gear reduces the turbine speed of 5700 r.p.m. to 2000 r.p.m. for the traction generators.

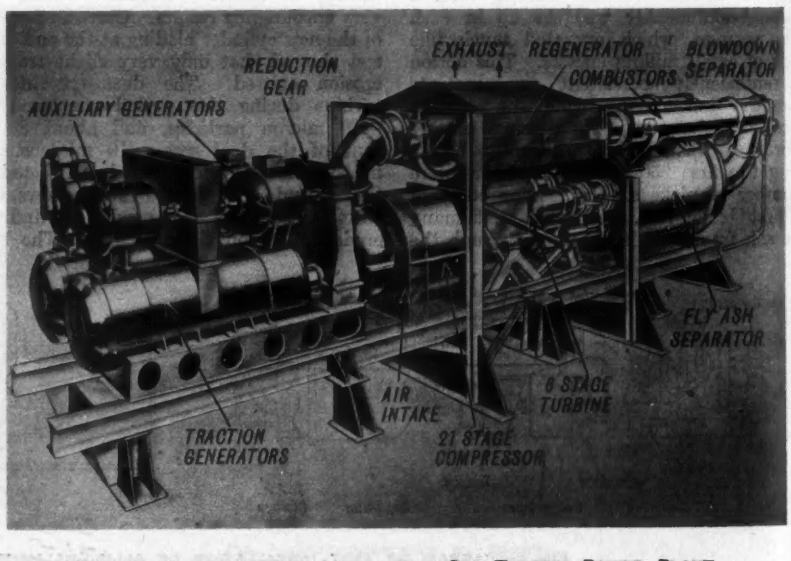


FIG. 11—ALLIS-CHALMERS LOCOMOTIVE GAS TURBINE POWER PLANT

Additional pinions in the gear system drive the two a.c. auxiliary generators as well as an exciter and a d.c. auxiliary generator. Four air-blown, variable-resistance grids have been installed to absorb the power produced by the traction generators. The plant may be operated either manually or automatically from the control station.

Combustion and Ash Removal System

The combustion and ash removal system, Fig. 6 *ante*, is similar to that developed for the Houdry turbine. Twin combustors are used because the height limitation precluded the use of a single large combustor. A louvre and a blowdown separator are installed at the end of each combustor. From the combustor outlet to the turbine inlet the entire system is subjected to the full turbine temperature of 1300 deg. Fah. It was decided that the tees, elbows and the separator shell should be made of Inconel X, an alloy which maintains excellent tensile strength up to 1400 deg. Fah., thus providing a margin of safety and making internal insulation unnecessary. Experience has shown that, with proper heat treatment, Inconel X can be machined and welded satisfactorily.

Test Programme

As soon as the initial operating difficulties have been overcome, a test of 250 to 500 hours' duration will be run at varying loads to determine the effect upon the turbine blades of air at 1300 deg. Fah., containing ash of −10 micron size. The blades of the locomotive turbine are made of "S-590" (20 per cent Cr, 20 per cent Ni, 20 per cent Co, 4 per cent Mo, 4 per cent W, 4 per cent Cb, 1·65 per cent Al, 0·75 per cent Mn, 0·65 per cent Si, 0·4 per cent C, remainder Fe), a high-temperature alloy considerably harder than the Houdry turbine blade alloy (19 per cent Cr, 9 per cent Ni, 1·25 per cent W, 1·25 per cent Mo, 0·75 per cent Mn, 0·5 per cent Si, 0·4 per cent Cb, 0·35 per cent Ti, 0·3 per cent C, remainder Fe). The last 250 hours of the Houdry test showed that blades of the latter material suffered only very slight erosion when operating at approximately 750 deg. Fah., but it now remains to be seen what effect the use of the higher air temperature will have in this respect. If the tests of the stationary locomotive turbine plant at Dunkirk prove successful, the power plant will be installed in a two-unit locomotive chassis. Extensive tests will then be run to determine the suitability of this form of motive power under actual railway service.

Manchester-Sheffield-Wath Electrification

DUNFORD BRIDGE TO WATH

No. III—(*Concluded from page 245, February 15th*)

Electrified working of freight trains between Dunford Bridge and Wath began commercially on Monday, February 4th, marking the first stage in the Manchester-Sheffield-Wath electrification. The complete scheme, which envisages a considerable increase in the capacity of the line by hauling all classes of traffic electrically, was begun by the former L.N.E.R. in 1936. *Because of the war construction was held up between* 1939 *and* 1947. *Electrification is by* 1500*V d.c. equipment and operation will eventually be by two classes of locomotive, with regenerative braking. At present only the* B_o-B_o *mixed-traffic locomotives are in service. They are described herewith and an outline of the electronic control of regeneration is given.*

THE locomotives* now in service are mixed traffic, double bogie, four-motor, four-axle (B_o-B_o) units, designated "Type EM-1"; since all axles are driven the total weight, of about 88 tons, is available for adhesion. Particulars of the rating, tractive effort and motor currents are tabulated herewith and the information is reproduced graphically in the accompanying locomotive performance curves. Our outline drawing shows the main dimensions and axle loadings and one of our photographs shows the general appearance of the locomotive.

Mechanical Parts of Locomotive

The fabricated steel bogies have at their outer ends a prefabricated assembly, which, with the buffer beam as a base, carries the buffers and drawgear, brake shaft and cylinder. At the inner ends a prefabricated unit forms a continuation of main frame and carries the articulation joint and hand-brake shaft on a common pin. The brake shaft and cylinder supports form part of this fabrication. By this arrangement the buffing and tractive forces are transmitted entirely through the bogies and articulation joint.

At the centre of each bogie a steel casting carrying the traction motor nose suspension brackets and the bogie centre control gear, is riveted to main frames. Each traction motor is axle-borne on suspension bearings. Single-reduction spur gearing (4·12 : 1) is used for driving the road wheels, the rim and the centre of the wheels being made in separate parts. On some of the locomotives these parts are connected by a system of helical springs, while on others the drive is transmitted through resilient pads. The plain bearing axle-boxes have manganese steel liners welded to thrust faces and the cast steel hornblocks are also fitted with manganese steel liners.

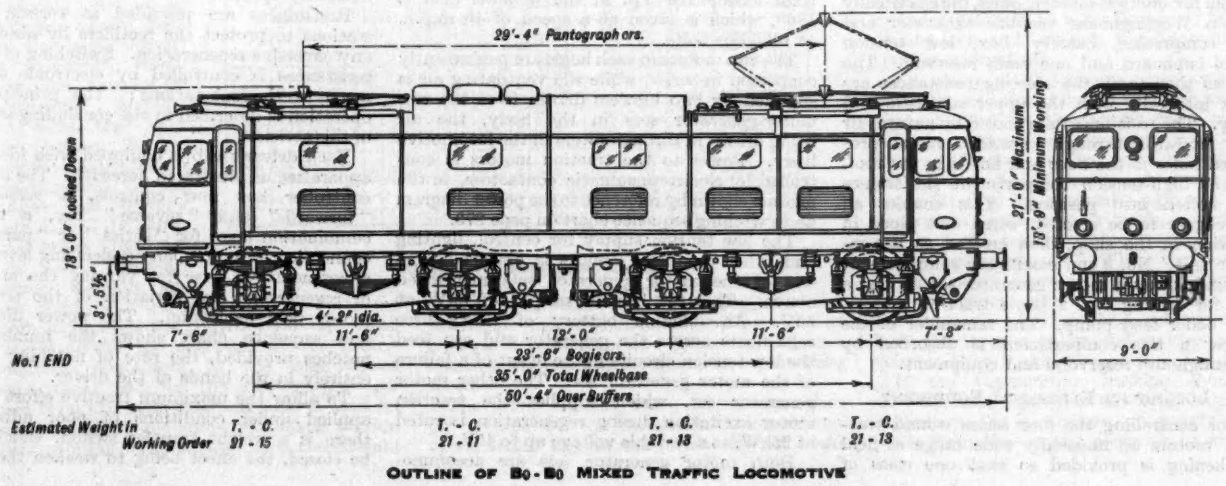
The understructure is built up with side-frame plates $\frac{1}{2}$in thick. The body and under-structure are spring-borne at four points on each bogie. A spring 4ft long with fifteen 5in by $\frac{1}{2}$in plates and a deflection of 0·21in per ton is pivoted on a bracket at the centre of bogie outside the frames. At each end of the suspension spring a piston in a suitable cast steel guide rests on a bolt that is adjustable for height; the piston top is arranged to take a semi-spherical bronze bearing pad that registers with a steel bearing plate on the upper

Main Characteristics of "EM-1" Locomotive

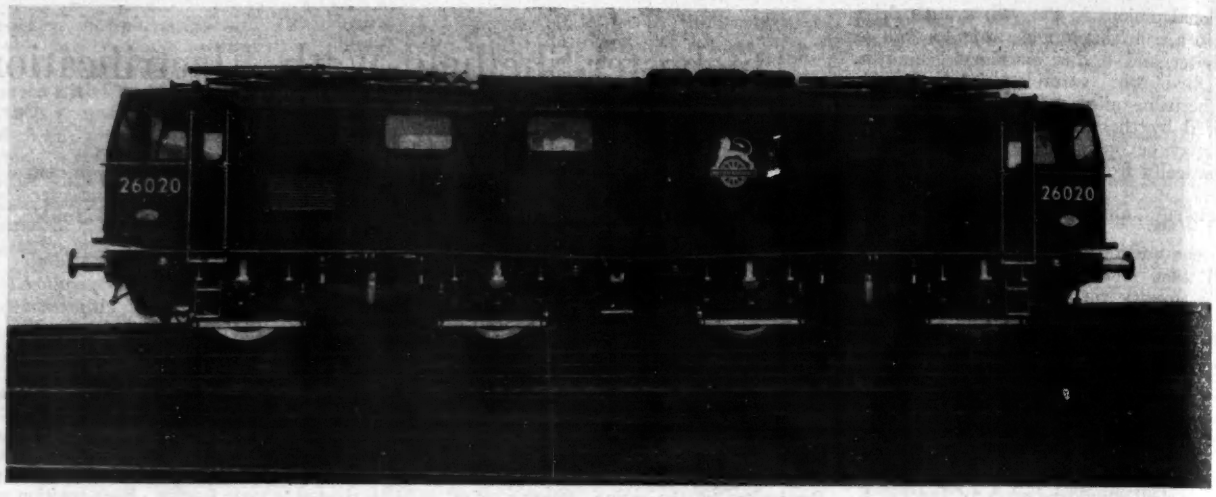
Rating	Total motor rating, h.p.	Speed, m.p.h. at 1400V	Tractive effort, lb	Motor current, Amperes
Weak field :				
Continuous	1,360	56	8,800	397
1 hour	1,868	45	15,400	540
Full field :				
Continuous	1,240	32	14,600	360
1 hour	1,740	26	25,100	510

Current	Tractive effort, full field, lb
Average accelerating current 700A	39,000
Peak notching current 750A	43,100
—	45,000 maximum starting value

* It may be recalled (The Engineer, February 24, 1950, page 249) that extensive operating experience has been obtained, since September, 1947, on the Netherlands Railways, with the prototype of these locomotives.



OUTLINE OF B_o-B_o MIXED TRAFFIC LOCOMOTIVE



B0 - B0 MIXED TRAFFIC LOCOMOTIVE

structure. This compensated method of supporting the upper structure gives the minimum body deflection for a given lift of any wheel.

A cast steel bogie centre bolted to the underside of the upper structure fits into a spherical housing, in which it is free to move up and down, and the spherical housing can turn with a universal movement in a containing block. This assembly is contained in a casting that slides in guides transversely under the restraint of controlling springs fitted with an initial load of 3 tons and ultimate load of 6 tons. It should be mentioned that the 1¼in side play of bogie centre is not required to enable the locomotive to take curves but is provided to fit the control springs with suitable loadings. The containing block with its spherical housing on No. 2 end bogie is free to move ½in longitudinally, sliding in a casting, to take care of the foreshortening of bogie centres on a curve.

Each axle is fitted with a mechanically independent set of clasp brake gear. A sandbox is fitted at each corner of the bogies. Sanding is effected by a foot-pedal in each cab, each box thus sands two wheels each side in either direction. Carlines riveted to the main frames of the under structure take the curved body sides and roof. The whole of the roof is detachable in five sections between the end cabs.

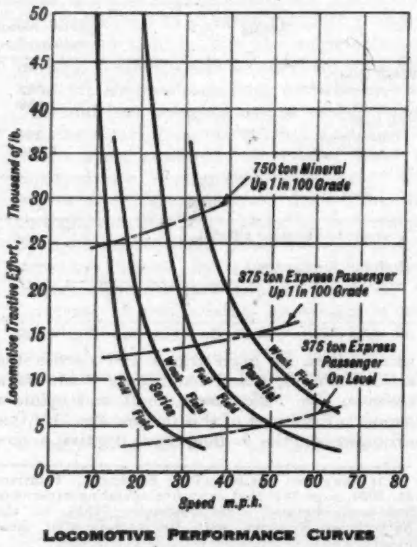
The locomotives have a driving cab at each end. Opening from each cab is a machinery compartment, connected by a side corridor, which, in turn, gives access to the resistance, high-tension and boiler compartments. The resistance and high-tension compartments are fitted with sliding doors that are mechanically and electrically interlocked by reverser key from the master controller, to prevent access except when the pantograph is lowered.

No. 1 end machinery compartment accommodates a motor-generator set that supplies the fan for traction-motor cooling, the electrically driven Westinghouse vacuum exhauster and air compressor, battery box, low tension panel cupboard and one main reservoir. The frames that carry the starting resistances are built integrally with the upper structure and body. The resistances are cooled by natural air flow upwards through expanded metal protected holes in the floor and hoods in the roof. In the high-tension compartment the frames are bolted into position. This enables all switchgear to be erected, wired and piped in position in the shop, then erected as a complete unit. No. 2 end machinery compartment accommodates a motor generator set driving a fan for cooling No. 2 bogie traction motors, and boiler feed pump. The remainder of the space in this compartment is absorbed by Westinghouse reservoirs and equipment.

Locomotive Electrical Equipment

For controlling the four series wound traction motors an unusually wide range of field weakening is provided so that one class of locomotive may handle a variety of traffic, including the heaviest mineral trains of 750 tons with one locomotive (850 tons assisted), all classes of goods trains with unbraked, partially braked and fully braked stock, and both stopping and express passenger trains. Maximum locomotive availability is thus achieved, which is especially important on comparatively short mileage electrifications such as the Manchester-Sheffield-Wath section.

The extensive range of economical tractive effort and speed thus afforded is illustrated by



LOCOMOTIVE PERFORMANCE CURVES

the accompanying characteristic curves. The total locomotive h.p. in the weakest field is 1868, which is given at a speed of 45 m.p.h. at 1400 line volts.

The two motors in each bogie are permanently connected in series, while the ventilating air is supplied by two blowers driven from the two motor-generator sets in the body, the air being drawn in through filters in the locomotive body. Power to the traction motors is controlled by electro-pneumatic contactors, in the manner shown by reference to the power diagram and switching sequence chart on page 273.

The low tension supply for control, lighting and other auxiliary circuits is obtained from one of the motor generator sets mentioned above. This set has an output of 5kW at 50V. An alkaline battery of thirty-three cells floats across the generator and can feed the low tension circuits in the event of a failure of the motor generator set. The other motor generator set, which supplies the traction motor excitation during regeneration is rated at 35kW, at a variable voltage up to 45V.

Both motor generator sets are accommodated in the auxiliary machine compartments, together with a motor driven compressor and an exhauster. The compressor, a two-cylinder reciprocating unit, supplies air for operating the locomotive brakes, the electro-pneumatic control apparatus, pantograph, horn, sanders and window wiper. The exhauster is a four-cylinder equipment for operating the brakes of vacuum-fitted trains and is arranged for two-speed operation, the higher speed being used for releasing the brakes.

Two pantographs are mounted on the roof, only one being used in normal operation. They are single-pan, spring-controlled, air-operated equipments. The main "pan" is fitted with an auxiliary "pan" which follows closely small variations in wire height. A manually operated air pump is provided to raise the pantograph in case of insufficient reservoir pressure.

Train heating is effected by an electric boiler, which is fed from a 240 gallon tank, and evaporates 1000 lb of steam per hour. Water is fed from the tank to the boiler by an electric pump, which is automatically controlled by water level. On those locomotives that are not fitted with electric boilers weight compensation is provided by a cast iron weight.

Regeneration

Regenerative braking is a logical expedient because of the long, heavy gradients over the Pennines (including Wentworth Bank with its 2 miles of 1 : 40), which characterise this line. For this purpose during regeneration one of the two motor generator sets supplies separate excitation of the traction motor series fields. Regeneration is provided down to a speed of 16 m.p.h. Below this speed regenerative braking ceases to function and the normal air brake is used. If regeneration should unexpectedly fail, the air brake is automatically applied.

Resistances are provided at certain substations to protect the rectifiers by absorbing any excessive regeneration. Switching of these resistances is controlled by electronic equipment in the substations; the principle of operation is described in the concluding section of this article.

Each driver's cab is equipped with identical apparatus, as illustrated herewith. The master controller has four controls, a removable "forward" and "reverse" key, a motor combination lever for "series" or "parallel" connection of motors, an accelerating lever and a regeneration lever for varying the amount of regeneration by variation of the traction motor field excitation. The power diagram and sequence chart shows the number of notches provided, the rate of notching being entirely in the hands of the driver.

To allow the maximum tractive effort to be applied under conditions of poor adhesion, there is a weight transfer switch, which can be closed, the effect being to weaken the field

of the leading traction motor in each bogie. This field weakening has the effect of reducing the tractive effort on the two leading motors, to an extent that matches the reduced weight on the corresponding axles caused by the tilting action of the bogies during acceleration. Then by notching up on the accelerating lever, effective use can be made of the maximum available tractive effort.

Braking

This locomotive was designed for one-man operation with deadman's pedal, to work express passenger and goods trains, all vacuum brake and close-coupled, and unbraked loose-coupled freight trains. These conditions call for a brake equipment capable of bringing all these different kinds of trains safely to a standstill from speed, without the sensitive control of an engine driver, and a Westinghouse vacuum controlled straight air brake with independent locomotive brake was developed for the purpose. The design is based on experience gained during the tests of a prototype locomotive on the Altrincham line in 1940.

The equipment consists of a system of air brakes and controls for vacuum brakes, suitably interconnected, whereby compressed air is used for operating the brakes on the locomotive and vacuum for operating the train brakes. Both systems have automatic action for deadman's emergency or breakaway.

Air from the main reservoir passes through a reducing valve set at 70 lb per square inch, into the brake-operating reservoir, which feeds the vacuum-air proportional application valve, the deadman's device, the regenerative brake failure apparatus and, via the straight air driver's brake valve, the automatic brake pipe. Air from main reservoir, passing through another reducing valve unit, set to 70 lb per square inch, feeds the control reservoir, which provides air for the operation of the electro-pneumatic contactors in the high-tension compartment and for the pantograph. Air direct from the main reservoir pipe is used for operating pneuphonic horns, pneumatic window wipers, sanding equipment and, via the straight air driver's brake valve, the straight air brake on the locomotive.

The straight air driver's brake valve is used to control the independent brake on the locomotive when hauling an unbraked train, when shunting or when the locomotive is running alone.

The vacuum driver's brake valve allows air to be admitted to the vacuum train pipe when a vacuum brake application is required. The main valve is rotary and the valve spindle carries a contact spider, which operates with contact fingers fastened to an insulating base within the body. When the driver's brake valve handle is moved to the application position a circuit is closed, which energises an electromagnetic exhauster cut-out valve isolating the exhauster from train pipe, thus preventing the exhauster from pulling against the brake valve. The brake valve handle is provided with a trigger-operated switch, which, in conjunction with the fingers, is so arranged that when the handle is in the release position and the trigger depressed, the exhauster is speeded up to a rapid release speed. When the trigger is released the exhauster returns to maintaining speed.

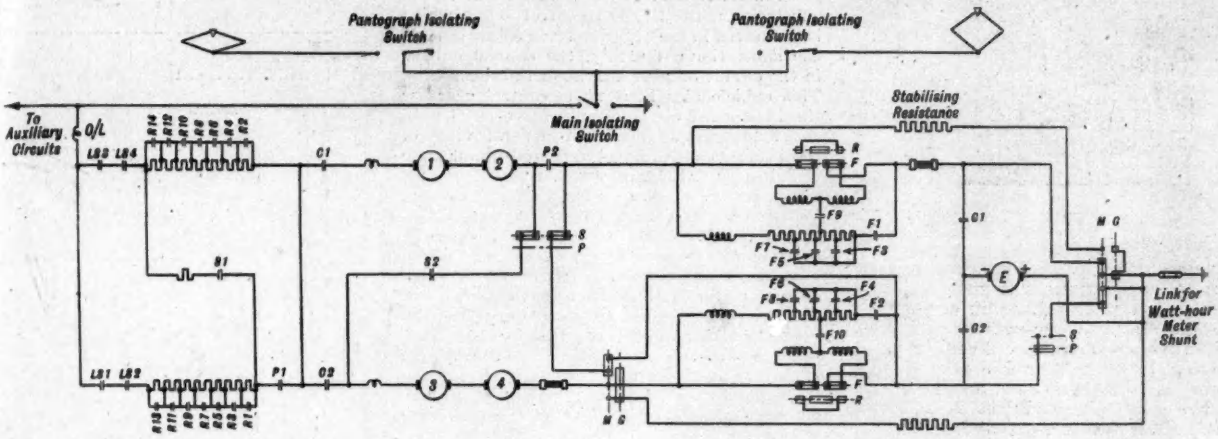
The driver's brake valve has a connection for a pipe to the vacuum-air proportional valve, which applies the locomotive air brake when a vacuum application is made on the train. This connection is in communication with the vacuum train pipe via a port in the rotary valve so that when the locomotive is in service with a vacuum braked train the connection is restricted. Thus, in the event of an application of the train brakes in emergency, operation of the proportional valve is slightly delayed.

When, however, one of the vacuum driver's brake valves is moved to either "release" or "brake on" position, the ports in the rotary valve allow the proportional valve to give locomotive brake applications or releases, suitably timed with respect to the normal vacuum brake applications on the train and under the control of the driver.

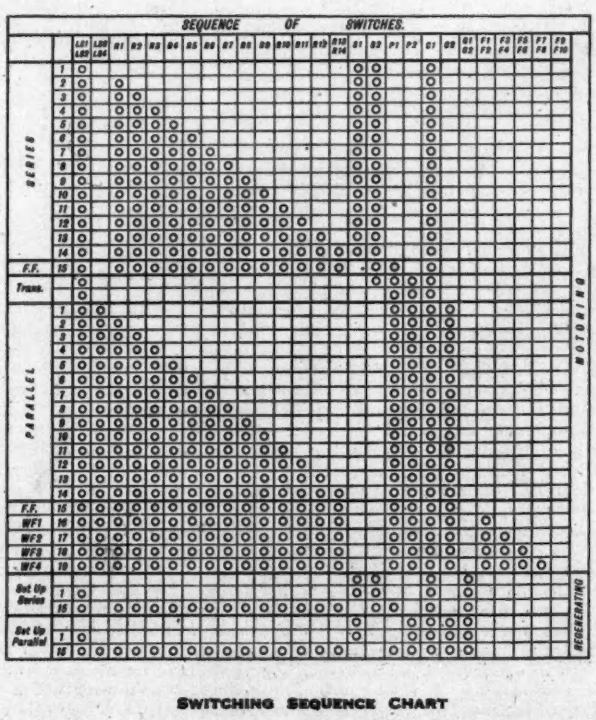
If the deadman's pedal is released, brake application is initiated after a delay of six seconds as follows. The automatic pipe is normally maintained at 70 lb per square inch, via the driver's brake valve, from the brake-operating reservoir. Air from the automatic pipe passes, via bogie hose connections, to a combined automatic valve and three-chamber reservoir and emergency reservoir on each bogie. Should this automatic pipe be vented to atmosphere either by operation of the deadman's device, which allows an emergency application valve to open, or by the placing of driver's brake valve handle in emergency position or by the failure of a bogie hose connection, the automatic valve begins to operate. The three-chamber reservoir contains an inshot reservoir and two timing reservoirs, and the first action of the valve is to allow air from inshot reservoir to pass to the brake cylinders, with which it equalises at 14 lb per square inch. This provides some retardation of the locomotive and the timing reservoirs then provide suitable delay, during which the wagons of a loose-coupled train may bunch up on the locomotive. After this delay the valve allows air from the emergency reservoir to feed to the brake cylinders, slowly building up the brake cylinder pressure to a maximum of 50 lb per square inch and bringing the locomotive and train to a standstill.

An air-operated vacuum emergency valve, normally held closed by air from the automatic pipe, is fitted to the vacuum train pipe. A timing reservoir and two-way cock enables this application to be suitably timed for passenger or freight trains. A control governor is fitted to the automatic pipe and, when a deadman's application is made, power is cut off from the traction motors and sanding is applied automatically. When the deadman's pedal is again depressed, after a slight delay, the emergency application valve is closed; the automatic pipe can then recharge together with the three-chamber and emergency reservoirs and the brake is released.

If the regenerative braking should fail an immediate equivalent air brake application is made on the locomotive. A supply of air is piped from the control reservoir to an "on"



Power Circuit Diagram



Switching Sequence Chart

type valve, which is mechanically depressed by an arm on the motor-generator drum reverser when it is in "Regen" position. Thus, when "Regen" connections have been set up, air can pass through the "on" valve to an "off" magnet valve, which is energised "closed" from the "Regen" drum of the master controller to "Regen" position. The circuit of the "off" magnet valve is completed through the over-voltage and overload relay contacts, so that, if either of these relays trips, the

DRIVER'S CAB

valve is de-energised "open," and air can pass through to a limiting valve set to 35 lb per square inch and thence to a relay valve, fed from brake-operating reservoir, which gives a corresponding pressure in the brake cylinders.

Electronic Regenerative Loading Equipment

Any regenerated power in excess of the amount that can be absorbed by "motoring" locomotives is dissipated by multi-stage resistances. There is one of these load-absorbing installations at Stafford Crossing and another at Barnsley Junction substation; similar units will be installed later at Gorton and Wharncliffe Wood. Each installation is capable of dissipating 600A of regenerated current at a nominal voltage of 1500V, the four resistances being rated at 150A each.

High-speed switching of each section of the loading resistance as required is effected by electronic means. The method of operation is illustrated in the simplified diagram herewith; it shows the elements of one only of the four stages, which are in parallel, and omits the auxiliary contactor gear. Briefly, when regenerative braking is used on a non-receptive line the resulting voltage rise is detected by a thyratron *A*, which immediately causes an ignitron *B* to fire and connect the loading resistance *R* across the 1500V track feeders. At the same time, the voltage across the coil of the contactor *G* falls to about 5V (one-third of the ignitron arc volt drop); the contactor *G* therefore drops out, whereupon the contactor *C* closes, short circuiting the ignitron and extinguishing it. The remaining three sections of resistance are similarly connected in sequence, with only a very short time delay between each section.

As the value of the regenerated current falls the four sections are disconnected in the reverse order, but overall timing controls are incorporated, to prevent the sections being disconnected until the end of a predetermined time interval, which is adjustable and need not be the same for each section. At the end of each time delay period control over the disconnecting of the loading resistances is transferred to two reverse current relays *D* and *E*. These relays are operated by a shunt *F* in the track feeder and their function, briefly, is to disconnect the resistances in turn, in accordance with the value of the current in the shunt *F*—that is, the regenerated current. Provision is also made so that when the local substation rectifiers are shut down the reverse current relays *D* and *E* are cut out of operation and disconnection of the loading resistances is carried out on a time basis only.

The loading equipment consists of four main pieces of apparatus: first, the electronic loading panel, which is installed in the ignitron room of the substation; secondly, the four loading resistances, housed in a separate room of the substation; thirdly, the control shunt which is connected in the negative track feeder outside the substation; fourthly, the control cubicle in the circuit breaker annexe of the substation. This cubicle also houses the control gear for the high-speed circuit breaker associated with the loading equipment. A general view of the loading control panel appeared in our issue of February 8, 1952, page 206.

The three installations for Stafford Crossing, Wharncliffe Wood and Gorton substations operate from a 3000A control shunt, while the equipment at Barnsley Junction substation operates from a 6000A shunt. The reverse current relays *D* and *E*, which operate in conjunction with the control shunt, are virtually contact-making ammeters; that is to say, the position of their contacts depends on the amount of regenerated current returned from the track: and the position of the contacts, in turn, determines the switching out of the resistance sections.

The function of the reverse current relays *D* and *E* can be appreciated by considering what happens when the four loading resistances have been connected to the track feeders, to absorb the excess power, as described above. It will be recalled that the minimum period for which each of the resistances remains connected is determined by a timing relay. After, say, two minutes, the timing relay associated with the fourth resistance opens its contact. Then, if the regenerated current still exceeds 430A, the loading contactor *C* will remain under the sole control of the relay *E* and the resistance will remain in circuit. But, if the regenerated current has already fallen to less than 430A, then the relay *E* will have opened its "right-hand" contact and the opening of the timing relay will have caused the loading contactor *C* to open, throwing off the loading resistance. In the meantime, auxiliary relays not shown in the diagram will have prepared so that the closing sequence can be repeated if the thyratron fires again.

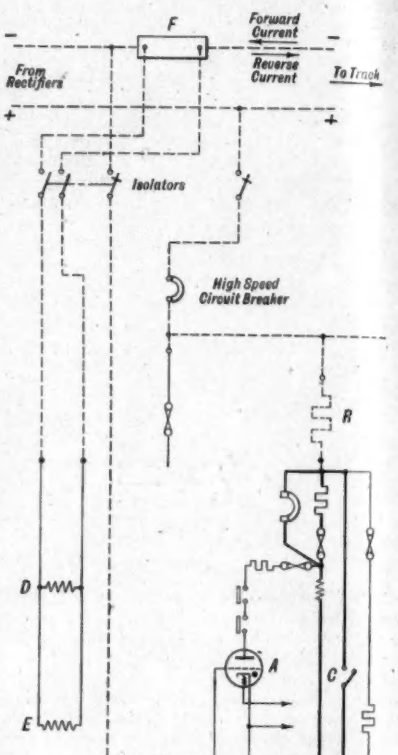
Similarly, at the end of, say, three minutes, the timing relay associated with the third resistance opens its contacts. Then, if the current is still above 280A the loading resistance still remains connected under the sole control of relay *E*. But if the current has fallen below 280A the relay *E* will have closed its "left-hand" contact and the opening of the timing relay contacts will have caused the loading resistance to be disconnected.

Similar sequences control the switching of the second loading resistance after, say, four minutes, and of the first resistance after, say, five minutes. For these two resistances the reverse current relay *D* comes into play instead of *E*, and the critical currents are 130A for the second resistance and 25A for the first.

So far we have considered the operation of the equipment under what we may call condition (1), requiring connection of the loading resistances consequent upon a voltage rise caused by normal regeneration with the local rectifiers in service. A second condition that requires to be satisfied is the connection of the loading resistances following a rise of d.c. busbar voltage caused by high a.c. voltage on no load, with the local rectifiers in service. There are two other conditions: (3) is similar to (1) and (4) is similar to (2), except that the local rectifiers are shut down in (3) and (4). These conditions will now be examined briefly.

Condition (2).—When a d.c. voltage rise occurs, because of high a.c. volts on no load, the loading resistances will be connected in the normal way as described above. There will, however, be no regenerated current from the track so that the relays *D* and *E* will both remain with their left-hand contacts closed. Each of the four sections of resistance will then be controlled solely by its timer and will, therefore, be disconnected after the preset time interval.

Condition (3).—If the local rectifiers are shut down, then, when the loading resistances are connected because of regeneration, the



Contacts of relays *D* and *E* not shown in diagram

ELECTRONIC CONTROL OF REGENERATION LOADING RESISTANCES

600A loading resistance current will flow through the control shunt in the same direction as the regenerated current even after regeneration has ceased. The control shunt will be unable to discriminate between forward and reverse current; the relays *D* and *E* will remain with their right-hand contacts closed indefinitely and the loading will remain connected. To avoid this difficulty provision is made for an "auxiliary" contactor to close when all the local rectifiers are shut down. This contactor then opens the circuits to the right-hand contacts of relays *D* and *E* and also seals across their left-hand contacts. The result is that the contacts of relays *D* and *E* are effectively in the same condition as if no regenerated current were flowing which means that the resistances fall under the sole control of their timers and are, therefore, disconnected on a time basis only.

Condition (4).—If the loading contactors are closed because of high a.c. voltage on no load when the local rectifiers are shut down, the condition will be similar to (3) above, and the auxiliary contactor again ensures that the loading contactors are opened to disconnect the resistances at the end of the timed periods.

It will be seen that, under conditions (2) and

(4), if the line volts are high during any period of no load, the loading contactors will continue to close and open in accordance with the dictates of the timing relays until the line voltage falls to such a value that will prevent refiring of the thyratrons.

Each of the four loading resistances is provided with a thermal overload relay to avoid damage by overheating. These thermal relays operate through the medium of isolating transformers which are connected in series with the coils of contactors in the anode circuits of the thyratrons. Overheating of the loading resistances opens the thermal relay contacts and the anode circuits of the thyratrons, operates the loading contactors, and disconnects the resistances. The relays are automatically reset when the loading resistances cool down.

Thermal overload relays are also provided for the protection of the fan motors that provide forced cooling of the loading resistances. It is arranged that the fan motor is shut down after the loading resistance has been disconnected.

The B.T.H. loading equipments described in this article are believed to be the first multi-stage electronically controlled resistance units to be put into railway service anywhere in the world, although some single-stage units for trolleybuses were commissioned by the British Thomson-Houston Company, Ltd., as early as 1937.

D.C. Switchgear

For the section now officially opened for traffic, the d.c. switchgear includes nine "rectifier," two "regenerative," twenty "feeder" and twelve "track sectioning" d.c. high-speed circuit breakers.

The cathode of each rectifier is connected to the positive busbar through a high-speed circuit breaker rated for 2000A continuously, and arranged to trip on "reverse" currents exceeding 2500A. The outgoing d.c. feeds to the overhead line are each made through a high-speed circuit breaker rated 1600A continuously, and calibrated in 500A steps from 3000A to 5000A to trip on excessive forward current. Similar breakers are installed at the track-sectioning cabins.

To facilitate maintenance, all the d.c. circuit breakers are shelf mounted, with brick dividing partitions and sheet steel front doors. The positive busbar and the isolators associated with each breaker are mounted under the shelves. All the high-speed circuit breakers on the system are B.T.H. "RJR" equipments, magnetically held and tripped by a series turn, diverting flux from the holding armature. These circuit breakers will completely interrupt a short circuit in less than 0·022 sec.

The control supply for the closing and holding circuits is taken from the 1500V busbars, the control equipment for each circuit breaker being enclosed in a cubicle with flush-fitting doors mounted opposite. The cubicles are bolted together to form a continuous line against the annexe wall. The panels are supported on large insulators and are hinged to give access to the back wiring.

Each rectifier circuit breaker is arranged to close automatically as part of the starting sequence, indications of the position of the breaker ("open" or "closed") being given at the control station at Penistone. The feeder and sectioning breakers are normally controlled from Penistone, but change-over and local control switches are mounted on each control cubicle to allow the breaker to be operated from inside the substation for maintenance and testing. The high-speed circuit breaker screens and the control cubicle doors are included in the comprehensive Castell interlocking scheme to prevent access to live parts.

Contractors

On the electrical side the main contractors and principal sub-contractors for the railway electrification (stage 1) were as follows:—Substations: main contractor, Bruce Peebles and Co., Ltd.; sub-contractors, A. Reyrolle and Co., Ltd., British Thomson-Houston Company, Ltd., Standard Telephones and Cables, Ltd. Cables: main contractor, W. T. Henley's Telegraph Works Company, Ltd.; sub-contractor, Standard Telephones and Cables, Ltd. Overhead line equipment: main contractor, British Insulated Callender's Cables, Ltd.; sub-contractors, Cargo Fleet Iron Company, Ltd., Redpath Brown, Ltd., Robinson and Kershaw, Ltd., Bullers, Ltd. Electric locomotives: main contractor, The Metropolitan-Vickers Electrical Company, Ltd.; sub-contractors, Westinghouse Brake and Signal Company, Ltd., Pritchett and Gold and E.P.S., Ltd. Penistone control room: main contractor, Bruce Peebles and Co., Ltd.; sub-contractor, Standard Telephones and Cables, Ltd.

For the civil engineering works, the firms listed below acted as the contractors and principal sub-contractors: Reconstruction of overbridges, Wellerman Brothers, Ltd., Dow-Mac Products, Ltd. Wath-on-Dearne locomotive depot, C. R. Price, Ltd., Doncaster. Penistone control station, C. R. Price, Ltd., Doncaster; Jacanello, Ltd., Henry Hope and Sons, Ltd. Substations, track, &c., C. R. Price, Ltd., T. Jenkinson and Sons (Doncaster), Ltd.

Fuels for Use in Marine Auxiliary Oil Engines

We summarise below the paper, entitled "Fuel for Use in Marine Auxiliary Oil Engines," which Mr. C. D. Brewer read before the Institute of Marine Engineers on Tuesday, February 12th.

Since the war the operating costs of ships have increased considerably, and this has given incentive to effect economies by using heavy fuels in the main engines. Versatility in respect of fuel requirements is most desirable in marine diesel engines, but the use of main engine fuel with the more fuel-sensitive smaller compression ignition auxiliary engines presents many problems, and the paper deals mainly with the use of a compromise fuel to give the greatest overall operating economy. Under-boiler quality fuels are taken into consideration and it is stated that their use in auxiliary engines is not likely to be satisfactory.

The available fuels and their properties are generally discussed and classified in a table including B.S.S. 209/1947 categories, in which class "A" approximates gas oils and class "B" are known as marine diesel fuels. Fuel costs are influenced by production economics governed by specification limits, so that gas oil is more expensive than marine diesel fuel and heavy fuels are the cheapest since viscosity is the principal factor. For high-speed engines quality control is necessary, but with increase in engine size, coupled with slower speeds, fuel characteristics are of less importance.

In selecting a fuel it is necessary to consider the influence of its characteristics on engine behaviour. It has been shown that the compression-ignition engine will function with practically the same brake thermal efficiency on all fuels that it can digest, but excluding those which cannot be properly atomised and those of low ignition quality. A graph of results illustrates the insensitivity of an engine in respect of brake thermal efficiency and differences in fuel characteristics. Ignition quality has been found to affect engine behaviour to a lesser extent than expected, and even in high-speed engines, fuels having a cetane number of greater than 45 behave well. A method of obtaining the cetane number is briefly described, and the results of experiments have shown that the cetane number of diesel and heavy fuels could be as high as that of some gas oils. The ignition quality is linked with the crude oil, paraffinic or asphaltic, from which the fuel is derived, and is little influenced by viscosity. Thus it appears that viscosity and ignition quality have little bearing on the choice of fuels. Fouling characteristics are important and the compression temperature and mean temperature of the operating cycle, as determined by the load, determine the ability of the engine to run on a particular fuel.

Concerning individual fuel characteristics, ring and liner wear increases linearly with the sulphur content, but tests have demonstrated that sulphur content is not necessarily the main cause of wear. Nozzle fouling is discussed with regard to Conradson carbon, sulphur and nozzle temperature, and also the cyclic formation of deposits. A record chart of laboratory tests reproduces the temperature of the exhaust of an engine operating under conditions favourable to deposit formation, and peaks in the curve illustrate the rise in temperature, due to nozzle tip deposits reducing combustion efficiency. Proper cooling of the injector to an optimum temperature and maintenance of the equipment, are necessary it is stated, if excessive fouling is to be avoided. Although the main engine is relatively insensitive to viscosity change the small auxiliary engine is more conservative, and both reliability and maintenance are sure to be affected if the new fuel used is of appreciably different viscosity. On this question of change in quality of fuel, exhaust valve failures have been noted in main engines after changing from heavy fuel to diesel fuel, when manœuvring, a phenomenon supported by laboratory tests.

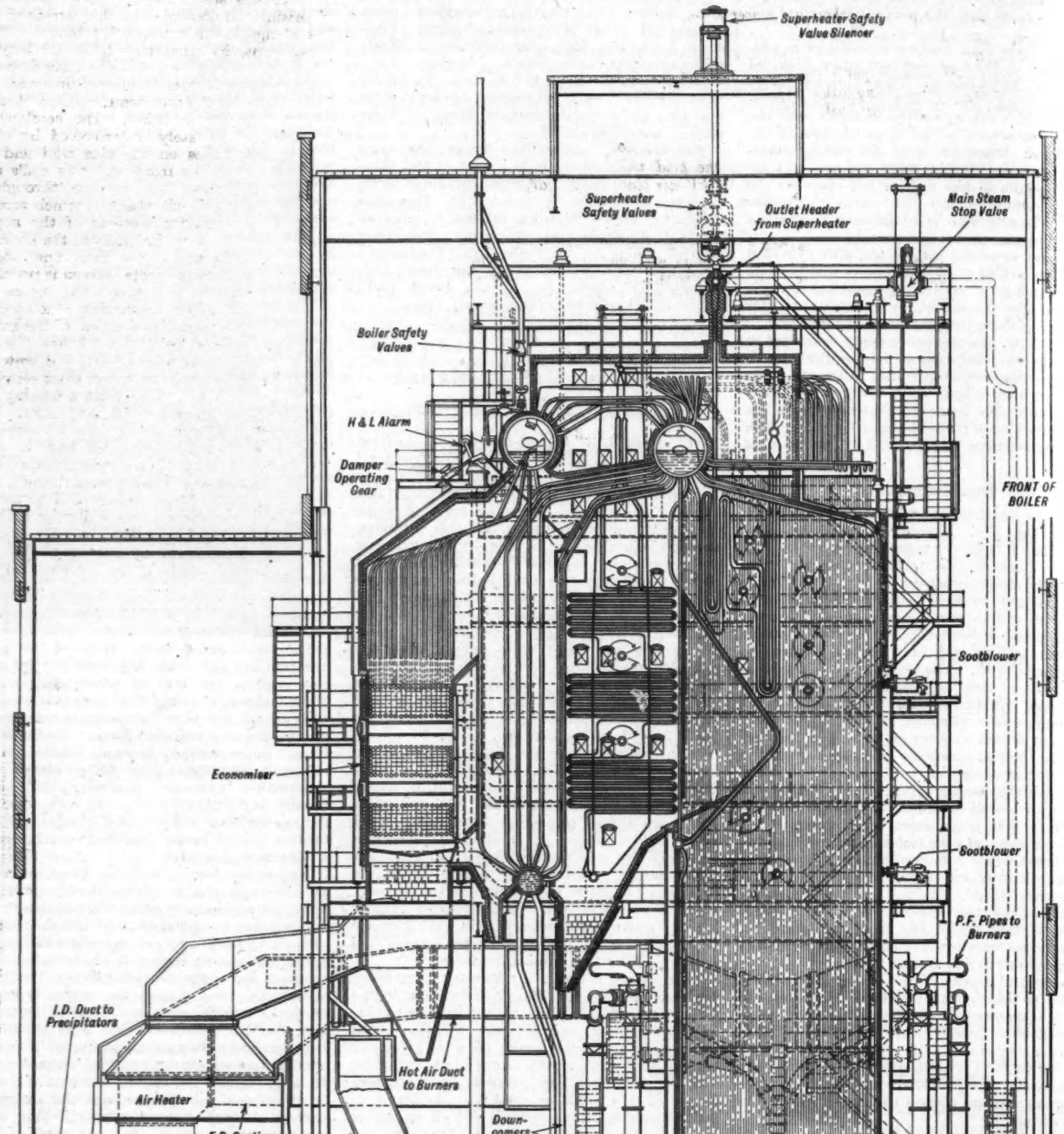
The low ash content of diesel fuels reflects the care taken at the refinery to remove mineral matter, but crude oil contains some inorganic ash-forming constituents and as the fuel becomes heavier there is a greater risk of abrasive matter being present. The harmful particles are those less than 6 microns in diameter; they will settle out from light fuel, but the settling process is too slow with heavy fuel, so that precautions had to be taken to prevent damage to injector equipment. The treatment of heavy fuel as advocated by John Lamb is recalled and his advice, concerning the use of centrifuges and clarifiers, reiterated.

The relationship between engine size and its fuel tolerance is given consideration, and short duration tests on engines of 212mm and 240mm bores showed that they could operate on heavy fuels provided they were preheated so that the maximum viscosity was 150 sec Redwood I at the injection pump inlet. Runs of 150 hours' duration did not reveal any defects. In small-size engines the rate of wear using marine diesel fuel can be nearly five times that observed with gas oil, but there is a reduced rate of wear by the use of chromium-plating for bores and rings. Supercharging has an influence on fuel tolerance; the higher mean temperatures affect combustion chamber deposits, the higher density and temperature of the compressed air reduces ignition delay, and the improved combustion should mean improved cleanliness and a reduction in wear.

Experience has shown that large main propulsion units can be operated successfully on heavy fuel. Medium speed and power auxiliary engines may be operated on all but the heaviest of fuels without much depreciation in performance, but not without risk of increased maintenance and reduced endurance. The paper shows that the influence on engine behaviour of fuel characteristics is dependent on engine size, but no correlation has been established between brake thermal efficiency, fuel consumption, and power output and feed characteristics. In large engines the sulphur content of the fuel is of reduced significance and the Conradson carbon content directly affects fouling in all but the largest engines, while the use of additive lubricating oils greatly reduces the undesirable results of operating on heavy fuels.

Ozone Treatment of Water.—For some time the Metropolitan Water Board has been carrying out experiments in the ozone treatment of water, with a view to ascertaining whether this is a practical method of treatment to adopt. The capital outlay and the recurrent cost of electric energy required for the generation of the high-tension, high-frequency electric power necessary for the ozonisation of water are very considerable. It was hoped that economies might be effected by the substitution of static electronic plant for that of the rotary type, which is expensive and of low overall efficiency. Considerable work has been undertaken with this apparatus, but the results obtained, it is stated, have been disappointing. The machine did not function in the manner expected, and the investigation was hampered by the difficulty of obtaining appliances of a special nature from manufacturers. In the circumstances, the Board has decided to discontinue the investigations.

DRAKELOW POWER STATION



CROSS SECTION OF 515,000 LB PER HOUR BOILER

Drakelow Power Station

The British Electricity Authority's power station under construction at Drakelow Park, near Burton-on-Trent, is designed for four 60MW hydrogen-cooled turbo alternators and four 515,000 lb per hour p.f. boilers. The inlet steam conditions are 1500 lb per square inch and 1050 deg. Fah., and the vacuum is 28·75in Hg. Circulating water will be taken from the River Trent and one cooling tower is at present being built. Work on the foundations was started in October, 1950 and the progress made since then is shown by the accompanying views from photographs taken in December last. There is provision on the site for a future station, Drakelow "B." Connection to the grid will be made at an outdoor switching station equipped initially with 132kV air blast switchgear, and switching at 275kV is envisaged in the future.

DRAKELOW "A" power station is being built on a site called Drakelow Park and bounded by the Walton-Burton road, the River Trent and the Leicester-Burton railway line, as shown on the accompanying plan. Circulating water for condenser cooling will be taken from the river and will be used independently or in conjunction with cooling towers. One tower is being built at present and the site lay-out provides for the addition of other towers later. The coal store and coal handling plant lie north of the station and between it and the main railway line.

The "A" station will accommodate four English Electric 60MW hydrogen-cooled turbo-alternators with a unit arrangement of four International Combustion 515,000 lb per hour pulverised fuel-fired boilers, the lay-out being shown in the accompanying plan. Associated with each boiler there is an electrostatic flue gas grit collecting plant with reinforced collecting chambers, housed in the station building, together with the i.d. fans, which discharge the flue gases into a brick chimney, serving two generating units. Between station "A" and the future station "B" will be the control room and office block, with a central workshop and ablutions block behind the control room.

Civil Engineering and Building Work

The whole site was excavated to an average depth of 6ft, thus providing the material necessary to form the embankments to the railway sidings and giving a mean level suitable for "A" and the future "B" stations whilst reducing the depth of the main foundations. This site levelling and removal of material was carried out at high speed, 300,000 cubic yards of earth being removed and levelled in under eight weeks. In general the foundations have been carried down to good marl, loaded at 3 to 4 tons per square foot.

In the south-west corner of the site, which is a low-lying area, sand and gravel workings are now proceeding, which supply the aggregate for the concrete work; later, when sufficient material has been removed, the quarry thus formed will be filled in by the ash slurry from the power station when in commission.

The turbine house, heater bay and circulating water pump annexe are being constructed entirely in reinforced concrete but the boiler house and relative bays are of structural steel. The cladding of the building is in Early English Blockley brickwork. Two brick chimneys are being built, each 360ft high, with an internal diameter at the top of 18ft 6in. The 132kV switching station is nearing completion so far as the civil engineering work is concerned, and is of precast concrete construction.

Rail-borne coal supplies will enter sidings arranged in the form of a triangle, with "empties" and "fulls" sidings, which connect to the Leicester-Burton line, and the lay-out is such that British Railways locomotives can draw the coal train right into the "fulls" sidings, reverse and pick up the empties. Each track can accommodate a train of sixty wagons and ultimately twelve tracks will be provided to both sidings, which will enable 6000 tons of coal to be handled per day. Seven miles of track have already been laid and flood-lighting will be provided to the sidings.

For station "A" the coal-handling plant will consist, briefly, of four wagon tipplers with bucket elevators, horizontal belt conveyors and inclined belt conveyors delivering coal to the bunkers. The tipplers will be capable of handling standard railway 24 ton wagons. A transporter of 188ft span will pick up coal from the store and will feed a belt conveyor, which takes the combined discharge from the four inclined belt conveyors serving the four tipplers. The capacity of each tippler and its conveyor is 120 tons per hour and the capacity of the conveyor to the store is 240 tons per hour. Extra coal storage will be obtainable by bulldozing from the area spanned by the transporter to an area under the cantilever portion of the transporter.

Boiler Plant

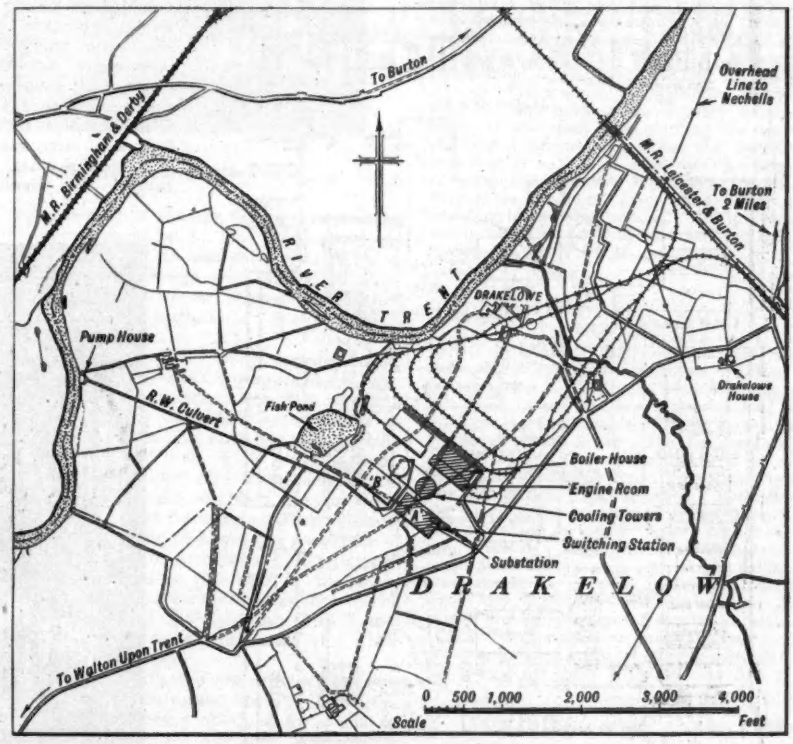
The four boilers to be installed in the first section of Drakelow generating station represent the most advanced operating conditions yet adopted by the British Electricity Authority. Each unit is designed to evaporate 515,000 lb of steam per hour at a pressure of 1550 lb per square inch and a temperature of 1060 deg. Fah. The design is based on the use of low grade Midland fuels having a gross calorific value, as received, of 8770 B.Th.U. per lb, with 21·5 per cent ash and 14 per cent total moisture. The ash fusion temperature, 2075 deg. Fah. in a reducing atmosphere, is low and this value, allied to the high steam temperature, has necessitated careful consideration to the furnace design to achieve the specified condition of being suitable for continuous operation for periods of up to fourteen months, with only on-load cleaning, and for two-shift operation when required.

The end-on arrangement of the turbo-alternator sets and the comparatively narrow width of the steam raising units allows the pulverising equipments to be arranged in lines alongside their respective boilers. This arrangement, in turn, leads to an economical lay-out of bunkers and coal elevating plant.

One of the boilers is shown opposite. It is of "Lopulco" three-drum radiant design, arranged for corner firing. The combustion chamber is completely water-cooled by close pitched bare tubes on the side wall and by finned tubes on the front and rear walls and roof. Gases leave the furnace through a specially designed exit channel, which screens the high temperature sections of the superheater from direct radiation from the combustion zone. To attain the high final steam temperature no water cooled screen is provided between the front and rear walls before the superheater. After traversing the widely spaced high temperature sections of the superheater, the gases, now cooled below the ash fusion temperature, pass vertically downwards through further banks of superheater elements and a small amount of convective heating surface to the economiser and air heater. The whole boiler and superheater unit is suspended from a rectangular structure and is completely free to expand in a downwards direction.

Feed, at 430 deg. Fah., passes through twin Heenan all-welded economisers and enters the feed drum at the rear of the boiler by multiple risers. Cool feed for the furnace walls is taken from the feed drum by means of 3in o.d. downcomers to the bottom boiler drum and by 5in bore pipes from this drum to the various wall headers. The risers from the side walls discharge into the front steam drum, the steam being delivered thence into the feed drum through three rows of 3in o.d. tubes.

The "Melesco" superheater is built up in five stages, all in series, three being in the low temperature zone and two in the high temperature. The elements of the first two low temperature stages are made from hot rolled mild steel tube, those of the third stage from chrome-molybdenum steel and the two high temperature stages from "18/8" chrome-nickel steel. The low temperature stages are arranged horizontally and the high temperature stages



DRAKELOW POWER STATION

are of pendant form. Control of the final steam temperature is automatically maintained within ±10 deg. Fah. by altering the vertical angle of tilt of the fuel burners. The resultant raising or lowering of the flame mass reduces or increases the furnace cooling surface presented to the gases, thus maintaining the furnace exit temperature at the required figure for the load on the boiler. Operation of the burner nozzles is performed by pneumatic cylinders, actuated by a Kent "Multelec" steam temperature recorder. Coarse control of steam temperature, to maintain it within the operating limits of the burner tilting device, is obtained by a manually operated, power actuated damper, which may be opened to bypass a proportion of the gases around the three low-temperature stages of the superheater.

After leaving the boiler proper, the gases divide into two parallel and identical streams, each circuit containing a Ljungstrom regenerative air heater, Sturtevant electrostatic precipitator and Davidson i.d. fan.

The coal pulverising plant comprises four "Lopulco" "L.M.16" mills per boiler, each driven by a 185 h.p. motor and swept by a Keith Blackman exhauster. Following standard "Lopulco" practice, each mill feeds one burner nozzle in each corner of the furnace, the nozzles being arranged to fire tangentially to an imaginary circle at the centre of the combustion chamber. The four nozzles in any one corner (one from each of the four mills) are mounted vertically one above another in a single casing, and are coupled together for simultaneous tilting by the Kent steam temperature controller. Two Wallsend Slipway pressure oil burners are fitted in each corner burner casing, the total capacity being sufficient to steam the unit up to a maximum of 80,000 lb per hour on oil alone. When firing the coal specified, maximum continuous load can be carried with three mills in service, the fourth acting as standby. The design permits the carrying of maximum continuous rating with coals containing up to 25 per cent total moisture.

Two Davidson f.d. fans deliver air to the preheaters, from which a portion is taken to the mills for drying the fuel and conveying it to the burners; the remainder is delivered around the burner nozzles as secondary air. The i.d. and f.d. fans, coal feeders and mill classifiers will be driven by Laurence Scott and Electromotors variable speed commutator motors, fitted with induction regulators. Alteration of the regulator position is effected from the control panel by a pilot motor. The furnace draught is maintained constant automatically.

To meet the onerous availability requirements special consideration has been given to the soot-blowing arrangements; eight retractable and two lance-type blowers are to be fitted in the combustion chamber, twelve lance-type blowers in the superheater passes, four traversing blowers for each economiser and four multi-nozzle blowers for each air heater. All blowers are arranged for electrical operation and remote, automatic control.

The main particulars of the boilers are tabulated herewith.

Particulars of Each Boiler Unit

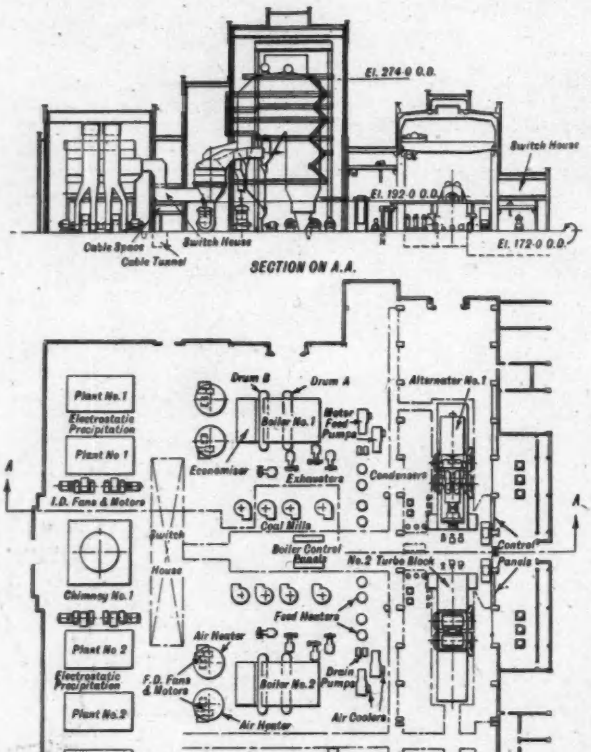
Evaporation, lb per hour	515,000
Steam pressure, per square inch	1,550
Steam temperature, deg. Fah.	1,060
Feed temperature, deg. Fah.	430
Combustion chamber volume, cubic feet ...	34,900
Combustion chamber heat release at m.c.r., B.T.U./cubic fo t per hour	19,150
Radiant heating surface, square feet	8,800
Convection	3,565
Superheater (high temperature)...	5,450
Superheater (low temperature)	29,500
Economiser (total for two)	39,168
Air heater (tota lfor two)	124,000

	Feed, ft in	Steam, ft in	Bottom, ft in
Boiler drums, internal diameter ...	5 0	5 0	2 6
Thickness	0 5	0 5½	0 2½
Overall length ...	38 8½	38 8½	29 11½
Tubes	3in o.d. × 0·358in thick		

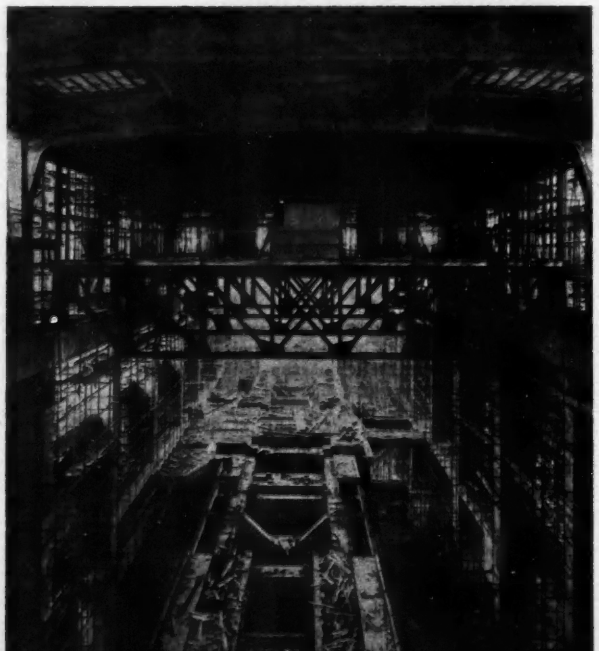
Each boiler unit will have two electrically driven constant speed Weir feed pumps, designed for 100 per cent duty, capable of handling 650,000 lb per hour against a pressure head of 1965 lb per square inch.

As the River Trent at this point is contaminated and is not suitable for boiler feed make-up water, two artesian wells will be bored through the sandstone and bunter beds, 15in bore, and to an anticipated depth of 600ft to 700ft, from which a yield of approximately 280,000 to 320,000 gallons per day is expected. Water from these wells will be pumped to a water softening plant, associated with which there will be two reservoirs of approximately 1,500,000 gallons. After treatment the water will be pumped to the treated water tanks situated in the station itself. For the complete "A" station three sets of Aiton and Co., Ltd.'s P. and B. triple effect evaporators are being installed, with a capacity of 25,000 lb per hour each.

The h.p. feed and steam pipes are also being provided by Aiton and Co., Ltd., using austenitic steel F.C.B.(T), supplied by Thomas Firth



POWER STATION PLANT LAYOUT

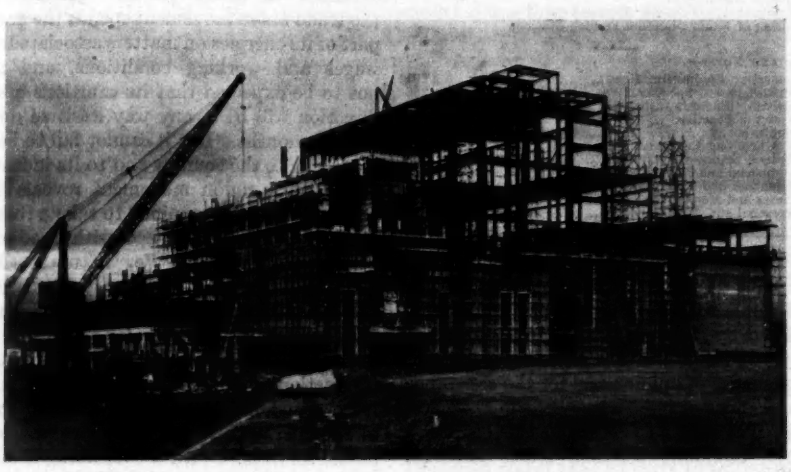


TURBINE HOUSE

and John Brown, Ltd., to withstand the working temperature of 1060 deg. Fah.

Turbo-Alternators

To obtain the full advantage of the heat drop available with the advanced conditions, the turbines are designed with the stages of expansion arranged in three cylinders, comprising a short, sturdy h.p. cylinder taking up the high temperature steam expansion, an i.p. cylinder and an outward double-flow l.p. cylinder of convenient lay-out to suit twin condensers. The alternator is of 60MW full output at 3000 r.p.m., 11kV, with hydrogen cooling, the coolers, two in number, being arranged longitudinally in the upper part of the alternator casing, which is of welded steel; axial flow fans mounted one at each end of the rotor circulate the hydrogen through the machine and coolers. There is no direct driven house alternator or exciter, the auxiliary supplies for the unit being obtained from a 6MVA, 11·8/3·3kV transformer directly connected to the alternator terminals. The exciter is separately driven by a 400 h.p., 3·3kV squirrel-cage induction motor and a stand-by exciter is provided for the complete station. The alternator windings are earthed through a 40 ohm liquid resistance.



Southern and Eastern Elevations of Drakelow Power Station

The anticipated steam consumption of each set is 7·939 lb per kWh and the anticipated heat consumption is 8808 B.Th.U. per kWh.

Each condenser consists of a twin shell unit with a cooling surface of 55,000 square feet and the feed heating plant comprises two l.p. stages, one of which is a de-aerator and four h.p. stages, giving a feed temperature of 430 deg. Fah. at m.c.r. The quantity of steam passed to each condenser is 354,000 lb per hour; the vacuum at exhaust flange is 28·75in Hg., and the quantity of cooling water required is 31,800 g.p.m.; the temperature of cooling water at inlet to condenser (river water) being 60·8 deg. Fah.

The circulating water system for the condensers has been designed so that any generator unit can use river water direct or can run on the cooling towers. The river water pump house is situated upstream and culverts are being constructed to deliver water to the ponds and associated culverts adjacent to the station; when the river is running full it may be possible to extract 8,000,000 gallons per hour, but as this section of the River Trent in normal dry weather flow is shallow and sluggish, this quantity is not then available for extraction.

At present only one cooling tower is being constructed, with the necessary ponds, suction and overhead culverts. It is designed for a water circulation of 3,800,000 gallons per hour and for the following conditions: recooled temperature, 76 deg. Fah.; temperature drop, 17 deg. Fah.; atmospheric dry bulb, 60 deg. Fah.; atmospheric humidity, 80 per cent.

The circulating water will be handled by four Drysdale constant speed vertical spindle, centrifugal pumps, each of 2,000,000 g.p.h. rating. The intakes will be fitted with four cup type circulating water screens supplied by F. W. Brackett and Co., Ltd.

Each alternator will be connected to a 72MVA English Electric generator transformer with a step-up ratio of 11·8/132kV, with delta connected primary and star connected on the 132kV side, at which voltage the machine is synchronised and switched. General station supplies and standby supplies to the unit auxiliary transformers are provided by 132/3·3 kV, 10MVA station transformers. All transformers are outdoor equipments fitted with conservators and naturally cooled, with the exception of the generator transformers, which are provided with two separate coolers with oil pumps and cooling fans.

The 132kV outdoor switching station comprises fifteen bays initially laid out for the accommodation of circuits for two generators, two station transformers, four feeders and one busbar coupler. The switching station is of a double busbar design with 3500MVA Reyrolle air-blast switchgear remotely controlled from the generating station main control room.

The Reyrolle auxiliary switchgear for works use is of single busbar truck mounted, air-break construction, solenoid operated, having a rating of 150MVA at 3·3kV and 25MVA at 415V. Each generating unit has unit turbine and boiler 3·3kV and 415V switchboards, to which are connected all the unit auxiliaries. Standby and starting supplies are provided from 3·3kV and 415V station auxiliary boards, there being one station board for each pair of turbo-alternators and boilers. A diagram type control panel is provided in the main control room for the control of supplies to the unit and station 3·3kV boards. The 3·3kV system is resistance earthed and the 415V system solidly earthed.

Direct current supplies are provided by two 800Ah lead acid batteries, each of 115 cells, charging supplies being obtained by means of two 20kW mercury arc rectifiers. Emergency charging of the batteries is arranged from the separate motor-driven standby exciter set provided for the main alternators.

Ash will be handled by gravity sluices inside the building to an ash pump house, in which are located three 3300 g.p.m. vertical spindle pumps. These pumps elevate the slurry to a gantry, which carries the troughs to the ash disposal area on the low-lying ground in the loop of the river. The sluice water is obtained either from the river culverts adjoining the station or from the overhead culverts of the cooling towers.

The construction of Drakelow "A" power station is being directed by the Generation Construction Department of the Midlands Division, the British Electricity Authority, under the supervision of Mr. F. W. Lawton, the Divisional Controller. The consulting civil engineers are L. G. Mouchel and Partners, Ltd. The main contractors are listed herewith.

Main railway sidings and preliminary works, Sir Robert McAlpine and Sons (Midlands), Ltd.; civil engineering and building work, Sir Robert McAlpine and Sons (Midlands), Ltd.; steelwork superstructure, John Lysaght (Bristol Works), Ltd.; brick chimneys, P. C. Richardson and Co. (Middlesbro'), Ltd.; cooling towers, Mitchell Construction Company; steam raising units, International Combustion, Ltd.; turbo-alternators, The English Electric Company, Ltd.; generator transformers, The English Electric Company, Ltd.; station transformers, British Electric Transformers, Ltd.; condensing and feed heating plant, Worthington-Simpson, Ltd.; boiler feed pumps, G. and J. Weir, Ltd.; artesian wells, C. Isler and Co., Ltd.; coal handling plant, Mitchell Engineering, Ltd.; ash handling plant, International Combustion, Ltd.; circulating water pipework, Aiton and Co., Ltd.; high pressure and temperature steam and feed pipework, Aiton and Co., Ltd.; overhead cranes, Clyde Crane and Engineering Company, Ltd.; river water pumps, Drysdale and Co., Ltd.; river water screens, F. W. Brackett and Co., Ltd.; electrofilter plant, Sturtevant Engineering Company, Ltd.; 132kV switchgear, A. Reyrolle and Co., Ltd.; 3·3kV and 415V auxiliary switchgear, A. Reyrolle and Co., Ltd.; main and auxiliary cables, British Insulated Callender's Cables, Ltd.; h.p. valves, Hopkinsons, Ltd.; quantity surveyors, Wood and Allsebrook.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

STEEL SPRING WASHERS FOR GENERAL AND ENGINEERING AUTOMOBILE PURPOSES

No. 1802: 1951. This standard covers requirements for spring washers for general use. Differentiation is made between "spring" and "lock" washers, the provisions of the standard applying to the former, not the latter. As it is primarily dimensional, an endeavour has been made to include a range of sizes which will suffice for general industrial use and cover most ordinary requirements, while at the same time limiting the number of different sectional sizes which the manufacturers will require to stock. Although the emphasis is on dimensions, clauses on suitable material, heat treatment, hardness testing and related manufacturing items are included. The provisions are not intended to apply to washers used by the aircraft industry. Price 2s., post free.

RUBBER CONVEYOR AND ELEVATOR BELTING

No. 490: 1951. This standard was originally published in 1933 and was revised as a War Emergency edition in 1943. The new document reverts, to a great extent, to the original standard of 1933, but now has five weights of fabric as well as three grades of rubber cover. The standard also gives details regarding the construction of the belting as well as stipulating limits for defects, tolerance, strength of fabric and adhesion. Methods of test are given in the appendices, where information is also contained regarding suggestions for the selection of belting; the appendices also contain recommendations about service conditions. Additionally, an appendix is included stating the information which should be given with the enquiry. In view of the present shortage of cotton, an amendment slip is being published simultaneously with the document, temporarily relaxing the strength of the fabric by 5 per cent. Price 3s., post free.

SOLID AND SPLIT TAPER PINS

No. 46, Pt. 3: 1951. This Standard was first published in 1929 and revised in 1935. In the present further revision the opportunity has been taken to enlarge the number of classes of pin to four and to extend the range to include larger sizes, thus covering nearly all the multitudinous duties for which these pins are so eminently suited. The details of materials and tests and the limits of tolerances on dimensions have been brought up to date. Two methods of nomenclature have been in use simultaneously, the one based on fractional sizes, the other on the number system. Such a condition having been considered unsatisfactory, it has been rectified by standardising the fractional method and making the number system non-preferred, but to ease the difficulties of those who have become used to the latter method the two have been compared in an appendix. To facilitate the selection of suitable drill sizes, appropriate information is given in another appendix. Price 2s. 6d. post free.

THE ENGINEER

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THE T.U.C. AND PRODUCTIVITY

THE Trades Union Congress has for long been looked upon as the "parliament" of organised labour in this country. At its annual assemblies a variety of matters of national and international interest are discussed, and the decisions which are taken indicate the attitude likely to be adopted by the trade unions on points of industrial policy. In the years which have followed the second world war—years that have brought a succession of economic and industrial problems—there has become evident increasing influence on the part of the T.U.C. in the various attempts which have been made to solve those problems. The general council of the T.U.C. has been frequently consulted by the Government; its representatives have taken their places beside representatives of employers' organisations on the many committees and councils which have been set up from time to time to examine questions of industrial production and exports, joint consultation, the cost of living, fuel and power supplies and the like; and on the measures for the nationalisation of industry which have been enacted since the war, the T.U.C. has, of course, had its full say. This increased participation by the T.U.C. in national affairs could, no doubt, be regarded as a natural consequence of six years of Socialist Government, and it might have been expected, with the coming into power of a Conservative Government last autumn, that changes in the T.U.C.'s attitude towards industrial policy would follow. But as soon as the result of the General Election was known, the T.U.C. general council referred to its long-standing practice to work amicably with whatever Government was in power, and added that "there need be no doubt of the attitude of the T.U.C. towards the new Government." The first tasks of that new Government have been by no means popular ones! It has been compelled to devise ways and means for correcting an economic situation which has become perilous in the extreme, and, at the same time, for proceeding as speedily as possible with the rearmament programme initiated by its predecessor. In those tasks, the Government has appealed for the support of all shades of opinion and for the assistance of both sides of industry.

In all attempts to deal with this country's critical economic position, much emphasis has properly been put upon the need for increased industrial productivity and the more efficient use of the nation's resources of materials and manpower. By the establishment—nearly four years ago—of the Anglo-American Council on Productivity, in the operations of which the Trades Union Congress, with the British Employers' Confederation and the Federation of British Industries, has taken a leading part, it was hoped that knowledge and ideas would be gained which could be usefully employed in the efforts to raise productivity. But, in addition to its participation in the activities of the Anglo-American Council, the British trade union movement has on many occasions in recent years declared itself keenly interested in problems of production and productivity. Many of those responsible for the conduct of trade union affairs are well aware of the desirability of fuller co-operation between managements and workers if industrial productivity is to be increased. A further pronouncement on the matter has, in fact, just been made by the Trades Union Congress in its monthly journal, *Labour*, which emphasises that "the people of this country will not be safe from attack or protected against the hazards of the world's economic weather if they allow their skills to go to waste instead of being employed to the nation's advantage." The T.U.C. goes on to suggest that if the numbers of the nation's workers cannot be raised, the level of their skill can be advanced by increased attention to training, supervision and productivity techniques. There may be "few new ideas to be gathered," but the T.U.C. thinks that what is wanted is the initiative to start using on a big scale the knowledge industry already possesses. Industry's own training schemes, the T.U.C. says, have proved "to be economical in time and money in raising the competence and, in turn, the earnings of many workers." It is therefore urged that trade unions will do valuable service to their country by joining with employers' associations in taking a fresh look at the possibilities of increasing the scope of such schemes. The immediate task, in the T.U.C.'s view, is "to see that everybody everywhere in this country is working without waste of energy, time and skill."

At a time like the present, when the country's industries are being continually urged to fresh endeavour, such advice as that tendered by the T.U.C. will be readily endorsed in many places. Traditionally, the trade union movement spends the greater part of its energies on matters associated with wages and working conditions, and it is not to be expected that its exertions in that direction will be in any way lessened during coming months. But it cannot fail to be encouraging to the country and to its industries if the trade union movement reveals itself more and more determined to take a realistic view of policies concerned with production and productivity. We, naturally, have always first in mind the particular needs of the engineering industry. Upon that industry there must rest the main weight of the rearmament programme, the claims of bigger production for export, and the equally important home demands for the equipment of the fuel and power, transport and other public services. With a continuing shortage of raw materials and skilled labour, the engineering industry—possibly more than any other—must keep on striving to employ its available resources more and more efficiently and economically. The effective support of the trade union movement in that effort is essential. The statement to which we have referred is another sign that the top executives of the trade union movement are fully convinced of the need for greater productivity in industry, though even they, we fear, cannot yet feel assured that their conviction is shared by the rank and file of trade unionism. If, however, the Trades Union Congress can still be looked upon as the "parliament" of organised labour, is it too much to hope that all its constituent members will demonstrate in practical manner that they readily and wholeheartedly support its declarations on so important a matter as working without waste of energy, time and skill?

TURN ROUND OF SHIPS

RECENTLY the Association of British Chambers of Commerce addressed a letter to Lord Leathers, the Secretary of State for the Co-ordination of Transport, Fuel and Power, stressing the urgency of the problem of slow turn-round of shipping and its hampering effect upon efforts being made to improve the financial and economic position of the country. The whole trend of post-war ship design has been towards increased speed, necessitating the installation of higher powered machinery and the adoption of finer hull lines. As a corollary of the smaller prismatic coefficient of the new vessels, there has had to be some sacrifice of hold capacity. But these faster

cargo vessels, some of which are capable of 18 knots, can complete more round voyages per annum. Despite reduced carrying capacity per voyage they are therefore able to transport a greater tonnage of goods per year. Unfortunately, however, this increased carrying capacity has been more than discounted by an increase in the time needed for loading and unloading at ports in many countries of the world.

Before the war ships generally spent two-thirds of their days at sea and one-third in harbour. To-day, these figures have been reversed and the consequence has been particularly detrimental to the economics of shipping. Indeed, delays at many ports have reached such serious proportions that some action is called for, more especially when the cost of building a ship to-day is considered. New tonnage represents a greatly increased amount of capital investment compared with pre-war days, and the drastically reduced sea time inevitably has meant, altogether apart from the effect of world events, an increase in freight rates in order that expensive new tonnage shall show some return commensurate with the capital outlay involved. In some harbours, the congestion of shipping has become so grave that heavy surcharges have had to be imposed in order to compensate the shipowner for loss of earnings due to the enforced idleness of his ships. Such an action does help the situation, but is only a palliative and not a cure. The slow turn-round of shipping can be attributed to the cumulative effect of many factors which differ from country to country and in individual ports. One main cause is the lack of equipment and the delay in the renewal of port storage and clearance facilities. These are factors which are aggravated by inadequate internal transport, shortage of rolling stock and lighters, increased flow of goods through re-orientation of trade, and, to some extent, by lack of co-ordination in packaging arrangements. Although these causes do exist, ships are equipped with efficient cargo handling gear and new cranes are reaching the ports—albeit somewhat tardily—so that greater expedition in handling might be reasonably expected. That however, is an expectation which is not being fulfilled. The main cause must therefore lie in labour conditions. They cover such items as restrictive practices, reluctance to make full use of modern aids, manning arrangements and lack of human endeavour. It is evident that the promotion of better industrial relations and understanding is essential, if a cure for these ills is to be found, and that a drastic change in ideas concerning mechanical handling is necessary in order that the general cargo ship may more nearly approach the happy position of oil tankers, which, by making a connection with a shore line, can either load or discharge by means of the ships' pumps.

To achieve a speedier turn-round of shipping, many suggestions have been put forward, such as the increased use of pallets and fork lift trucks, the shipping of cargo in standard containers, and, in order to save space, the adoption of a standard 'tween deck height to match that of the containers. This latter method has, incidentally, the advantage of considerably reducing losses sustained by pilfering which have been on a large scale in recent years. Other suggestions which have been advanced include the "Mezzo" portable 'tween deck; the fitting of portable lifts in the hatchways; the adoption of the "Siporter" system, and even the building of vessels having machinery aft and detachable cargo holds forward. All these schemes and many others are worthy of consideration, but the adoption of any of them would require adjustment and adaptation to the various trades and port facilities, and such work would obviously call for a considerable amount of co-operation on an international basis. Many authorities and companies concerned with the handling of cargo have been giving serious consideration to the problems involved in speeding up the transport of goods and, in October of last year, a committee was formed as a first step towards solving the problem of port delays and to study the overall question of the handling of cargo, with maximum efficiency, from the factory to the consumer. Interest in the idea has proved world wide and should the endeavours of the International Cargo Handling Co-ordination Association prove successful, then the results cannot fail to be of benefit to all. For the effect of delays in the turn-round of ships is not confined only to the shipowner, but has repercussions right along the line to the production point and beyond.

Obituary

WILLIAM SEBASTIAN GRAFF-BAKER

It is with regret that we have to record the death on Friday last, February 15th, of Mr. William Sebastian Graff-Baker, the chief mechanical engineer (railways) of London Transport. Mr. Graff-Baker was born at Baltimore, in the United States, on November 14, 1889, and received his general education at St. Paul's School, London, Cleobury Mortimer College, and the John Hopkins University, in the United States. In 1908 he entered the City and Guilds of London Central Technical College, where he gained the A.C.G.I. Diploma and a B.Sc. (Eng.) degree.

It is not surprising that, at the end of his technical education, Mr. Graff-Baker turned his attention to electric traction, for both his father and his grandfather were builders of electric street railways and electric tramways, the former in America and the latter in this country. He entered the service of the Metropolitan District Railway as a junior electrical fitter when he was twenty years old, and from then to the time of his death was concerned with railway transport in London. After a relatively short period as an electrical fitter he was appointed an assistant to the mechanical engineer in 1912 and a year later was placed in charge of all lifts and escalators on the London Electric Railway and the Central London Railway. In 1921, after serving some months as personal assistant to the mechanical engineer, he was made car superintendent. A year was spent in this capacity, when he was appointed an officer on the Underground group of companies with the title of assistant mechanical engineer. He retained this post after the formation of the London Passenger Transport Board in 1933.

In February, 1935, Mr. Graff-Baker became the chief mechanical engineer (railways) of the Board and from then till his death he was responsible for the design, construction, maintenance and overhaul of all the rolling stock, lifts and escalators of London Transport.

During his term of office Mr. Graff-Baker was primarily concerned with the introduction of the many improvements which have taken place on the railways of London Transport, and have made for rapid, safe and comfortable travel on both the surface and tube lines. He was responsible for the design and introduction of all the improved designs of rolling stock now running on, or on order, for the lines, including the lightweight District Line stock now being placed in service. One of his important contributions to the design of electric rolling stock was the tube stock, introduced on London Transport in 1938, with roller axle and suspension bearings, and improved cam-operated electrical control equipment. His flair for invention and design led to the introduction of faster escalators, more efficient automatic door equipment, and faster and roomier trains, as well as many other developments which have made the London Transport rail system second to none.

W. S. Graff-Baker

In addition to being an engineer of repute, Mr. Graff-Baker was a man of wide interests with many friends, and he was well known in several technical societies. Although he was naturalised shortly after his education in this country, he maintained a close contact with the United States and was a member of the American Society of Mechanical Engineers. He contributed many papers to the leading professional institutions and, indeed, it was but little more than a month ago that he read his paper "Considerations of Bogie Design, with Particular Reference to Electric Railways," before the Institution of Mechanical Engineers in London. In addition to being a member of the Institution of Mechanical Engineers, he was also a member of the Institute of Transport and the Institution of Locomotive Engineers.

R. J. W. COUSINS

We regret to have to record the death of Mr. R. J. W. Cousins, which occurred on Saturday last, February 15th, at 320, Upper Shoreham Road, Shoreham-by-Sea. Mr. Cousins, who was sixty-eight, had been chief designer of Ricardo and Co. (Engineers), 1927, Ltd., for many years.

Richard Joseph Walsh Cousins was born at Bangor on January 8, 1884, and received his general education at the Xaverian

Brothers School, Manchester. For his technical studies he attended the Manchester College of Technology and the Kendal Technical School. In 1901 Mr. Cousins began a three-years' premium apprenticeship with Gilbert Gilkes and Co., Ltd., of Kendal, and on its completion remained with that firm for a further two years, spending one year in the shops and a year in the drawing-office. He then joined Isaac Braithwaite and Sons, Ltd. Kendal, as a draughtsman, with which firm he worked for nine years or so, mainly on automatic laundry machinery.

Mr. Cousins's long association with Ricardo and Co. (Engineers), 1927, Ltd., actually began during the first world war. He enlisted in the Royal Flying Corps in 1915 and was subsequently put on to technical work. This led to his being assigned, in 1917, to Engine Patents, Ltd.—the predecessor of Ricardo and Co., Ltd.—for work associated with Sir Harry Ricardo's appointment as consultant to the Air Ministry. On demobilisation in 1919 Mr. Cousins was offered a post in the laboratory established at Shoreham-by-the-Sea by Ricardo and Co., Ltd., first taking charge of the drawing-office and shortly afterwards becoming chief designer for the company. Among work for which Mr. Cousins was responsible during his long period of service at Shoreham, was the detail design of the first standard variable comparative fuel test engine, and the torsional lay-out of many large auxiliary sets for cruisers and battleships. He also designed the first automatic fuel-air controls for the Whittle jet aircraft and the sensitive speed control for its turbine.

Since 1938 Mr. Cousins had been a regular contributor to *Kempe's Engineers' Year-Book* on the subject of internal combustion engines. He was elected a member of the Institution of Mechanical Engineers in 1948.

GEORGE BARNARD

We have learned with regret of the death of Mr. George Barnard, M.I.E.E., which occurred at his home, "Moorfield," Hagley Road West, Birmingham, on February 7th. Mr. Barnard, who was in his ninetieth year, had been associated with British Insulated Callender's Cables, Ltd., and its predecessors for the whole of his long working life. He joined W. O. Callender, Ltd., in 1880—the firm which preceded Callender's Cable and Construction Company, Ltd.—and after a short period in the works at Belvedere, Kent, was transferred to the outside staff, being engaged mainly in the laying of vulcanised bitumen insulated cables.

Mr. Barnard next became the company's supervising contract engineer and for some years was responsible for the carrying out of cable laying contracts in this country and on the Continent. In June, 1890, he was appointed to take charge of the laying of the first cables for the Birmingham Electric Supply Company, a job which led to his becoming engineer and manager for Callender's Cable and Construction Company, Ltd., in the Midlands. In that appointment Mr. Barnard served for over fifty years, and took responsibility for many important cable laying contracts in a number of Midlands cities and towns. In 1932 Mr. Barnard was appointed an advisory director of his company, taking an active part in its affairs until his retirement, at the age of seventy-nine, in December, 1941.

Opencast Coal Production.—A written Parliamentary reply by the Minister of Fuel and Power says that the National Coal Board has agreed to take over operational and financial responsibility for the production of opencast coal, as from April 1st.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TECHNICAL (OR "TECHNOLOGICAL") UNIVERSITIES

Sir,—The columns of the technical and non-technical Press have for some time been bestrewn with endless disputes on the above subject. But I am under the impression that few of those who know the Continental "technical universities" from their own experience have had a chance to comment on the various criticisms, based in most cases upon either prejudice or ill-apprehension of the organisation and activities of these institutions. I am sorry to find that what is said on the above subject in your recent leader ("Discovery and Invention," February 8th), also tends to neglect obvious facts and to present the reader with a misleading picture. I hope, therefore, that as an outsider, and without the slightest intention of recommending anything to anybody, I can be permitted to make the following comments in defence of "technical universities." These are wholly based upon my own experience as a former student of a technical university, and also on personal knowledge of various establishments of this type located between Stuttgart in South-West Germany, and Moscow in Central Russia.

(1) *Terminology.*—The term "technical university" has probably been invented by newcomers from the Continent for the sole purpose of avoiding lengthy explanations regarding the standard of their degrees to potential British and American employers. The description "technological" in lieu of "technical" became fashionable only recently, in the course of the present dispute. Provided one knows what kind of institution he has in mind the question of labelling it is entirely immaterial.

(2) *Organisation.*—The majority of the great higher technical schools were founded seventy-five to one hundred years ago. Their far-sighted organisers apparently realised the specific problems, future expansion and ever-growing importance for a national economy of these establishments. They apparently also felt that it may not be the best policy to downgrade the technical sciences by reducing their status to that of an appendix to a faculty of "natural" or "exact" science comprising pure mathematics, botany, theoretical physics, paleontology, &c. Finally, they may have suspected that the governing bodies of the old universities, headed usually by lawyers and doctors of divinity, might regard the newly created departments as kinds of second-class step-children, and hinder or neglect their development.

Consequently, they decided to establish separate institutions and give them full university standing and prerogatives.

This was a wise step because in this way the rapid expansion of various engineering sciences and technologies could be adequately matched by erecting new faculties, departments and chairs headed by top-level experts in their respective fields. Continental faculties of mechanical or civil engineering have usually a dozen or more chairs, just as is the case with faculties of medicine throughout the world.

(3) *Teaching.*—The minimum duration of a degree course is from four (Germany, Switzerland) to five years (Italy, Belgium, Russia). On top of "fundamental" knowledge the student receives a sound and comprehensive training in a few optional disciplines supported by a large amount of project—and laboratory work. Workshop technology and machine tools, and the design of cranes and handling machinery form major disciplines in any mechanical engineering curriculum of university standard. Mechanical and electrical students are taught a lot of metallurgy, and vice versa. Civil engineering students have a subject called "Machines in Building Industries," and so on. It is not considered sufficient for a technical graduate to know a lot of formulæ and to imagine machines and structures as combinations of straight lines and full or dash-dotted circles. He must be conversant with the accumulated practical knowledge in order to understand how to use the "principles." Otherwise, he will forget the fundamentals before he has the first chance of making use of them.

(4) *Post-Graduate Studies.*—As far as I know, systematic post-graduate courses do not exist on the Continent for the simple reason that they are unnecessary. The knowledge acquired during the normal studies is sufficient to start useful work in industry immediately after graduation.

(5) *Research Higher Degrees.*—The amount of research work turned out by Continental technical institutes per head of university population is certainly less than in Great Britain. This is due to several reasons. First, the institution of financially sponsored "research students" is on the Continent practically unknown (Russia is an exception from this rule, and a limited number of "aspirants" for higher degrees is accepted in the larger technical "institutes," selected on the basis of an open competitive examination). Second, the number of students in the individual departments is large and the equipment is occupied by current students' work. Thus research is carried out almost exclusively by members of staff. Alternatively, many of the researches are prosecuted in autonomous affiliated institutes which are virtually independent, in spite of the fact that they are nominally a part of the university framework. The above applies in the first place to various material research stations and testing establishments often run on commercial or semi-commercial lines and employing full-time salaried staffs.

The majority of the higher degrees (Dr. Ing.) are obtained as a result of extramural work in industrial establishments, submitted in the form of a thesis. For this reason most of the dissertations deal with problems of practical interest.

(6) "*Specialisation.*"—A reasonable amount of specialised knowledge in addition to "fundamentals" is extremely useful because it enables the young engineer to choose the right type of employment, and vice versa. Specialised courses arranged in works, while useful, are often lacking the objectivity which can be secured by a university course. They may also be influenced by competition outlook and advertising ends.

(7) *Technical Universities and Industry.*—A Continental "technical university" is, in the first place, an educational establishment and only in the second a research institute. Its prime function is to turn out economically (i.e., with the maximum use of the available staff and equipment) large numbers of high-standard graduates capable of tackling immediately live technical problems. Industrialists, managers and rank and file workers are graduate-conscious, and fully realise the importance of the graduate engineer in industry. The degree of saturation of production and design departments with graduates is very high. Claims that graduates in technical sciences have not their feet on earth, or that they have to be re-educated before they can be of use, are extremely rare. Also, in the vast majority of cases the young engineer who takes his first job feels that he got from his studies just the kind of knowledge he required. "Graduate apprenticeships" do not exist nor are they needed, anyhow.

I hope that the above remarks will help to

correct some of the misconceptions which may have arisen in the course of the debate on the subject of "technological universities."

N. H. Polakowski, Dipl. Ing.

Swansea,
February 14th.

The National Research Development Corporation

The report of the National Research Development Corporation for the year ended June 30, 1951, has now been published and it states that its liaison with the sources of invention throughout the country, which are in receipt of public money, is now functioning smoothly and harmoniously. Scientific workers were found to be increasingly aware of the need to avoid prejudicing a nationally advantageous discovery by publication prior to making a patent application. This has enabled the Corporation to collate and fit inventions into an embracing subject pattern in a given field. The corporation at the time of the report held or was in process of acquiring some 897 patents covering a wide variety of fields. From amongst the projects needing substantial development expenditure two particular projects are selected for comment. One of these projects is the electronic digital computer, which, it is considered, may have considerable industrial importance in the future, quite apart from its use to mathematicians. A close watch, it is stated, is being kept on all developments in this field, ensuring that adequate patent cover is available. Some eighty inventions covered by British and foreign patent applications were vested or being vested in the Corporation. These patents came from many sources, but the majority originated from the School of Electrical Engineering at Manchester University, under Professor F. C. Williams. The second project quoted in the report deals with the potato harvester designed by Mr. P. J. Packman, and a development company, known as Packman Harvester Developments, Ltd., with a panel of technical advisers nominated by the Ministry of Agriculture and the National Institute of Agricultural Engineering. Experience has indicated that development expenditure will be low on the earlier years of the Corporation's existence, but will increase as the number of inventions accumulates and as individual inventions mature. The report points out that although it is yet too early to give any forecast of what the Corporation's expenditure may rise to, the £5 million contemplated as expendable over its first five years will probably not be reached unless some quite unforeseeable need arises.

BOOKS RECEIVED

Chill-Cast Tin Bronzes. By D. Hanson and W. T. Pell-Walpole. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 75s.

Punched Cards. By Robert S. Casey and James W. Perry. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 80s.

Instrumentation of Open-Hearth Furnaces. London: George Allen and Unwin, Ltd., Ruskin House, 40, Museum Street, W.C.1. Price 30s.

Mathematical Engineering Analysis. By Rufus Oldenburger. London: Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 45s.

Gas Turbine Theory. By H. Cohen and G. F. C. Rogers. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 30s.

Manufacture of Iron and Steel, Vol. 2. By G. Reginald Bashforth. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 45s.

Simplified Mechanics and Strength of Materials. By Harry Parker. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 35s.

Filing and Indexing. By O. W. Standingford. London: Office Management Association, Management House, 8, Hill Street, W.1. Price 5s.

Year Book of the Heating and Ventilating Industry, 1951. London: Technitrade Journals, Ltd., 8, Southampton Row, W.C.1. Price 7s. 6d.

Model Steam Locomotives. Revised edition. By Henry Greenly. London: Cassell and Co., Ltd., 37/38, St. Andrew's Hill, E.C.4. Price 15s.

Gas Turbine Locomotive No. 18,100

No. III—(*Continued from page 239, February 15th*)

The main elements of the 3000 h.p. gas turbine locomotive No. 18,100 having been dealt with in some detail, we now give some particulars of the principal auxiliary equipment and of the control apparatus. In the notes on the control equipment, its functions during normal running of the locomotive and its operation under emergency conditions are described.

Auxiliary Equipment

Most of the auxiliaries are electrically operated from the 110V d.c. supply from the auxiliary generator. The battery, consisting of forty-eight lead-acid cells of 384Ah capacity, is charged from this supply through a contactor, which is closed only when the auxiliary generator is generating. Certain of the electrical auxiliaries are battery fed and can be run at any time, whilst others are fed from the generators and can be used only when the turbine is running.

Fuel and lubricant are supplied to the turbine by a pumping set consisting of a 10 h.p., 3000 r.p.m., battery fed motor, driving a fuel pump overhung from the motor and a lubricant pump mounted on a common bed-plate with the motor. There are two of these sets, both carried on the main turbine bed-plate. One set works at a time, but it is automatically superseded by the other set in the event of a failure of fuel or lubricant supply. The swash plate fuel pump can supply 7·5 gallons per minute at 650 lb per square inch, and the lubricant pump is designed to deliver 70 gallons per minute at 50 lb per square inch.

The auxiliary fuel pump is driven at 1400 r.p.m. by a ½ h.p. battery fed motor, the complete unit being mounted adjacent to the main turbine bed-plate. This pumping set supplies fuel from the tank on the locomotive underframe to the suction side of the main fuel pump. Its gear pump is rated at 10 gallons per minute at 10 lb per square inch. A similar auxiliary lubricant pump is mounted on the turbine bed-plate and supplies oil to the turbine and gear bearings during the cooling period after the turbine has been shut down.

The heat carried away from turbine bearings and from the reduction gear in the lubricant is dissipated in a cooling equipment comprising two air blast radiators. These radiators consist of rows of wire-wound cooling tubes extending between top and bottom headers. One radiator is mounted in each side wall of the locomotive body, and air ducts in sheet aluminium sweep inwards and upwards from the radiators to converge at the entry to an axial-flow, vertical-axis 32½in fan mounted in the roof. The fan is driven at 1480 r.p.m. by a 10 h.p. series motor fed from the auxiliary generator, and it draws about 16,000 cubic feet per minute of air through the cooling elements. The heat dissipation capacity of the radiators is approximately 120kW with 70 deg. Fah. ambient and 180 deg. Fah. lubricant entry temperature.

A two-cylinder, single-stage reciprocating air compressor driven by a built-in 8 h.p. motor supplies compressed air at 100 lb per square inch for operating the locomotive brakes, the electro-pneumatic control apparatus, sanders, warning horns and window wipers. An automatic governor switches the compressor motor on and off to maintain the pressure in the main reservoir between 85 lb and 100 lb per square inch.

The vacuum brake equipment on the locomotive operates at 24in and two reciprocating four-cylinder exhausters provide the braking power for the train. Each exhauster is driven by a flange-mounted motor at 750 r.p.m. for normal vacuum maintenance, and brake application, and at 1200 r.p.m. for release. Both sets come into operation in the event of an emergency application of the brakes. The swept volume of each exhauster is 82·5 cubic feet per minute at 750 r.p.m., and the power input is 4 h.p. The two machines are capable of creating 25in of vacuum in a train having 80 cubic feet train pipe and cylinder capacity in forty-five seconds. Current for the exhauster motors is supplied from the batteries in order that the brakes will not be applied by the shutting down of the turbine in stations or when coasting.

The three traction motors in each bogie are force ventilated by a centrifugal blower directly coupled to a 11·25 h.p. motor. This blower delivers about 8000 cubic feet per minute of air at 6in water gauge when running at 1460 r.p.m. The air is distributed to the motors through sheet aluminium ducts on the floor of the underframe and flexible leather bellows extending down to the motor air inlet flanges.

Steam for train heating purposes is supplied by a vertical fire-tube, oil-fired boiler continuously rated at 1500 lb per hour, 80 lb per square inch. The operation of the boiler is semi-automatic in that the fuel flow is controlled by the steam demand and the feed pump delivery is regulated by the water level, the fuel being cut off by loss of flame and by low-water level. To ensure flame stability with the air pressure fluctuations occasioned by high train speeds and the effects of bridges and tunnels, a high-pressure combustion air blower is provided in conjunction with flow retarders at the inlet and outlet of the firebox.

The 40,000 cubic feet per minute of air required for the gas turbine at full load is drawn through filters built into the side walls of the turbine compartment. These dry fabric filters can be cleaned when necessary either after removal from the locomotive or by reverse blowing in position by compressed air nozzles on flexible pipes which are provided in the turbine compartment. It is not expected that this air filtration will eliminate the need for compressor blade cleaning, but it will materially reduce the rate of fouling.

In the driving cabs the auxiliary equipment includes pneumatically operated window wipers, double-note pneumatic warning horns, electric foot warmers, electric food heaters, and a plenum system of cab ventilation and heating. The ventilation air is tapped from the adjacent traction motor ventilation trunk and is conducted by a dual duct to a combined mixing valve and "Punkah louvre" set high up in the cab back wall. In one section of the dual duct a thermostatically controlled electric element heats the air. The driver can manipulate the louvre to get the required quantity, direction and temperature of air.

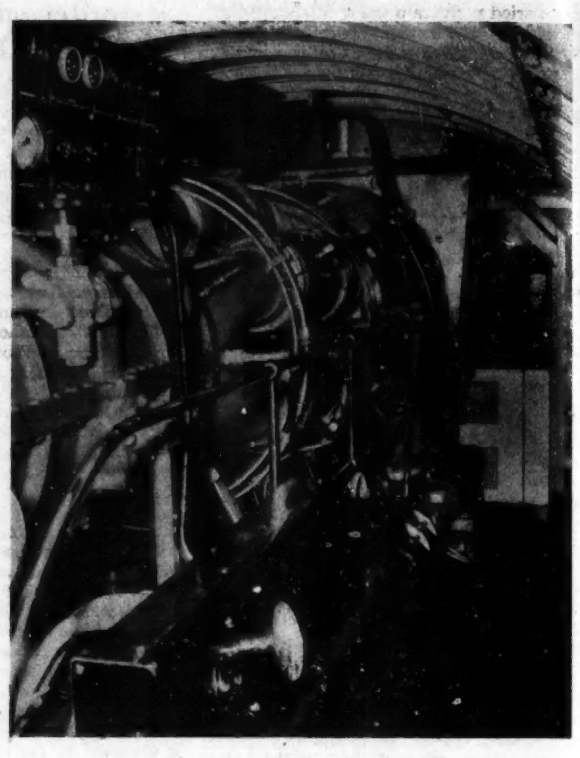
A combined fuel and boiler water tank slung under the body underframe and between the bogies is of elliptical cross section and constructed throughout of welded steel plate. In this tank a transverse division plate separates a 995-gallon fuel section from a 620-gallon water section. Both sections can be made available for fuel by removing a cover from an aperture in the division plate. Remote reading tank contents gauges are operated by tank floats, and electrical potentiometers with indicators are fitted in each driving cab and at the tank filling valves.

It will be seen from the drawings that, with the exception of the tanks, all the auxiliary equipment is housed inside the body portion of the locomotive, and is grouped mainly in the driving cabs and the adjacent ends of the turbine and generator compartments. In the photograph of one side of the turbine compartment which we reproduce there can clearly be seen the turbine, flame tubes and the compressor with its air intake ducting.

The Control Equipment

The main function of the control equipment is to provide means for the driver to control the speed of the train by regulating the tractive

THE DRIVER'S CAB



GAS TURBINE COMPARTMENT

effort developed at the wheels. At the cost of some elaboration of apparatus the control scheme has been designed to require from the driver the minimum of concern and responsibility for the functioning of the power plant and auxiliaries. The principal electrical circuits are shown in the diagram on this page, and the controls can be seen in a photograph of one of the driving cabs.

When a driver takes over the locomotive he simply operates the key switch and presses the turbine start button. When a green light appears one minute later it indicates that the turbine is running at idling speed, and then the driver switches on the brake compressor and exhausters.

The locomotive is ready for service after about five minutes' warming period if the start is made from cold. To move the locomotive after the brakes have been released, the reversing lever of the master controller is moved to the direction required and the power lever set to the position required. This lever has no notched positions, but can be set and left at any position between no power and full power. For the sake of convenience and simplicity, the same lever has been arranged to determine the starting tractive effort developed between the minimum for light locomotive manœuvring and a maximum determined by wheel slip consideration. The driver is not required to notch up this master lever as the train speed rises; he can do so if he so wishes, but may equally well put it directly in the position he expects ultimately to require.

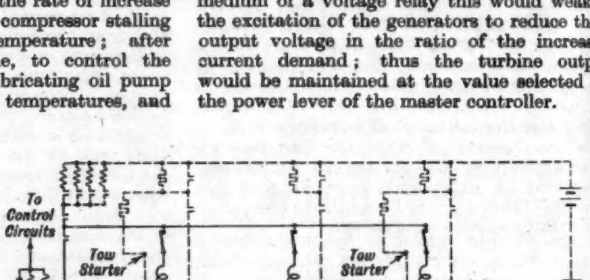
To simplify the driving technique in this way the control equipment has been designed to perform the following functions during normal locomotive operation:—

Start the turbine (which involves the sequence of starting the auxiliary fuel pump, starting the main fuel and lubricating pumps, switching on the turbine igniters, opening the fuel isolating valve, connecting the starting battery to the main generators, adjusting the generator field strength as the turbine speed rises and eventually disconnecting the battery at the appropriate time and switching off the ignition); start the lubricating oil cooler fan and the traction motor blower motors; control the recharging of the battery; open the fuel control valve in accordance with the position of the driver's power lever; adjust the field strengths of main generators and traction motors to the changing speed of the train and in accordance with the power lever position; in the event of the locomotive speed being too low for the power selected (resulting in excessive tractive effort) to limit the tractive effort to the maximum determined by the power lever position and to adjust the fuel valve accordingly; for any power lever position, to adjust the turbine speed to that most economical for the power demanded; for any demand for power increase, to regulate the rate of increase of fuel within the limits for compressor stalling and turbine maximum temperature; after shutting down the turbine, to control the running of the auxiliary lubricating oil pump to avoid excessive bearing temperatures, and after shutting down the turbine, to control a series of periodical low speed runs by battery power to prevent turbine rotor distortion during cooling.

In addition the control equipment must deal with such emergency conditions as the following:—

In the event of the battery state of charge being insufficient to start the turbine, to provide means for utilising external power in the form of towing by another locomotive to effect a start; if a breakdown of the automatic output control occurs, to provide a simple form of output regulation at reduced power on the natural characteristic of the generators; in the event of failure of the running main fuel and lubricant pump set, to start up the standby set; in the event of excessive turbine inlet gas temperature, to reduce the fuel supply rate; to cut off the fuel if overspeed of the turbine occurs, and in the event of electrical insulation failure or overcurrent to open the electrical circuits and cut off fuel.

The general method by which each of these functions is performed is to relate to each quantity to be regulated a proportionate voltage and to cause that voltage to control relays and electric servo means for adjusting the quantity to the required value. If, for example, the traction conditions changed so as to demand a higher tractive effort, as in reaching a rising gradient, the increase of current to the traction motors from the main generators causes the turbine speed to drop. This condition would immediately be reflected in a reduction of voltage from a tachometer generator driven by the turbine. Through the medium of a voltage relay this would weaken the excitation of the generators to reduce their output voltage in the ratio of the increased current demand; thus the turbine output would be maintained at the value selected by the power lever of the master controller.



SIMPLIFIED POWER CIRCUIT DIAGRAM

The sequence and timing of the various events in the process of starting the turbine are determined by a drum sequence controller driven by an electric motor. Similar means are employed to regulate the periodic running of the turbine during cooling. The auxiliary lubricant pump operation is under thermostatic control.

In the case of the automatic output control breaking down, the assistant driver would perform the function of a governor by keeping the turbine speed roughly constant by using a manual fuel valve situated adjacent to a tachometer on the turbine instrument panel. With the turbine speed regulated in this way the power output

would be varied with train speed in accordance with the inherent characteristics of the generators, exciter and motors, as determined by the combination of the three exciter field windings, and whilst never reaching the normal value, is adequate for an emergency.

If the battery is unable to start the turbine certain electrical connections can be changed so that by pushing or pulling the locomotive by another engine the traction motors can be used to supply the power normally available from the battery. Electrical faults are dealt with by overload relays and an earth leakage relay in the main circuits and by fuses and circuit breakers in the auxiliary circuits.

In the main power circuits the apparatus used is the same as for an electric locomotive. For example, each traction motor is controlled and protected by an electro-pneumatic unit switch, and its field is reversed by an electro-pneumatic drum switch. The auxiliary circuits also are controlled by conventional electric traction apparatus, but as new conditions are met with in the subsidiary control and regulating circuits, special devices have been designed to deal with them. For instance, the principal components of the master controller are low-voltage potentiometers. Their function is to apply to servo devices in the control circuits voltages proportional to the response required by the position in which the driver has placed the control lever. These servo devices are of the vibrating contact design and they control field strengths and servo motors to produce the desired result.

In addition to the gas turbine and electrical equipment, the Metropolitan-Vickers Electrical Company, Ltd., has built the locomotive mechanical parts, reduction gear and oil coolers. The following equipment has been supplied under sub-contract by other firms:—

Brake equipment, air compressor and vacuum exhausters, Westinghouse Brake and Signal Company, Ltd.; machining and assembly of bogies and provision of some bogie components, Yorkshire Engine Company, Ltd.; train heating boiler, Spanner Boiler Company, Ltd. (Laidlaw-Drew-Spanner burner); wheels and axles, Taylor Brothers and Co., Ltd.; axleboxes, Hoffmann Manufacturing Company, Ltd.; springs, Jonas Woodhead and Sons, Ltd.; buffers, Geo. Turton Platt and Co., Ltd.; Hydraulic dampers, Girling, Ltd.; swing link resilient units, Metalastik, Ltd.; draw-buff, motor suspension and other resilient units, Silentbloc, Ltd.; aluminium alloy, James Booth and Co., Ltd.; pneumatic warning horns ("Desilux"), C. V. Desiderio, Ltd.; battery, Chloride Batteries, Ltd.; air filters, Vokes, Ltd.; blowers for traction motors, Keith Blackman, Ltd.; cooler fan for lubricating oil, Davidson and Co., Ltd.; main fuel pumps, Dowty Equipment, Ltd.; main lubricant pumps ("Imo"), Mirrlees (Engineers), Ltd.; auxiliary fuel and lubricant pumps, Varley Pumps and Engineering, Ltd.

The Storage Pumps of the Etzel Power Scheme, Switzerland

No. I

The conservation of surplus power through the medium of pumps raising water to elevated reservoirs is an effective method of cutting down the power waste which occurs in base-load hydro-electric stations at times of high water. The two five-stage pumps at the Etzel power station, which work against a head of some 1600ft, are described in this article; their effect on the performance and economy of the station is examined.

THE Etzel hydro-electric power scheme in the Canton of Schwytz, in Central Switzerland, exploits the difference in altitude between the artificial Lake Sihl and the upper reaches of the Lake of Zurich. Lake Sihl, which is fed by a river of the same name, lies in the neighbourhood of the small town and monastery of Einsiedeln. Just over 5½ miles long, it has an average width of 1400 yards and a surface area of nearly 4½ square miles. Its effective storage capacity is about 3400 million cubic feet. With a maximum water level at the dam of 2929ft and a mean water level of 1343ft for the upper Lake of Zurich, the maximum gross head is 1586ft. The water from Lake Sihl first passes through a tunnel 3215 yards long into the surge tank, and from there through a double pipe-line, 2400 yards in length, down to the power station in the vicinity of the village of Altendorf.

Six vertical Pelton turbines with two inlets each are installed in the power station (Figs. 1 and 2), giving outputs of 18,000 to 22,000 h.p. each at a net head between 1381ft and 1568ft. The total output at present is therefore about 120,000 h.p. When the intended extension is carried out and two additional sets installed, the output will attain 160,000 h.p.

Three of the turbines are direct coupled to single-phase generators of 18MVA each at a frequency of 16⅔ c/s and a terminal voltage of 10kV, which supply current to the Swiss Federal Railways. The other three turbines are coupled to three-phase generators of the same output and terminal voltage, but with a frequency of 50 c/s. The current produced goes to the general supply network of the Nordostschweizerische Kraftwerke A.G. The generators are installed below the floor of the machine hall, with only the exciters above floor level. The transformer plant is situated in the open air alongside the machine hall and raises the generator current to the voltages required for the transmission lines, the highest of which is at present 150kV.

The tunnel, pipe-lines and tail race are dimensioned for a maximum flow of 1130 cubic feet per second. The power station itself is 270ft long, 85ft wide and 108ft high and is built on sandstone and marl. The tail race, which is 465 yards long, takes the form of a tunnel 16½ft wide and 15ft high up to a point about 60 yards from the lake, whence it widens up to 30ft in an open channel.

The annual power supply from the station is normally 152 million kWh, of which 110 million is available in winter and 42 million in summer. In years of medium to high water up to 53 million kWh of additional power can be obtained from surplus water.

A scheme for the installation of pumping plant with a total discharge of about 175 cubic feet per second, was prepared when the Etzel power scheme was planned in 1932–33. As, however, both the Swiss Federal Railways and the Nordostschweizerische Kraftwerke A.G. were hesitant as to whether use could be made of the extra production from the pumps, the pumping plant was not at first installed, though space was left for it in the basement of the power station. The pumps were actually ordered in 1945, when the increasingly severe electricity shortage made it clear that their installation was justified.

It is a characteristic of the Etzel power scheme that in years of normal precipitation and even in moderately dry years, Lake Sihl is filled during the summer months by the inflow from natural sources alone. Only in very dry summers, such as those of 1947 and 1949, does the natural inflow of water to the lake fail to fill it. It is accordingly only in very dry years that the pumping plant can be used for accumulating water for winter use. In normal times it serves principally for balancing the supply of electricity over short periods, rarely exceeding a few weeks. Nevertheless, as the following paragraphs will show, the performance of the whole station has been substantially improved by the storage pumps. They are also of great value in complying with certain regulations regarding the dates by which the lake must be filled, failure to comply with which would involve heavy fines. The operation of the pumps has hardly any influence on the water level of the Lake of Zurich, which is lowered at the most by a few inches.

It is clear from Fig. 3, which represents the filling of Lake Sihl for a number of years; that the water pumped into it in the summers of 1947 and 1949 was used in full for the generation of electricity in the following winters, whereas the water pumped in spring, 1948, overflowed during the high-water period in July and was thus lost. Losses of this kind are one of the unavoidable risks of hydro-electric schemes and are likely to remain so, since the inflow fluctuations due to precipitation and the spring thaw must always be a matter of speculation. If surplus night and week-end power is available for the pumps from the base-load stations (Fig. 4), however, the short-term equalisation of the power supply may be of value not only in summer, spring and autumn, but in many cases also in winter, when the waters are at their lowest. The power supply situation was, for instance, extremely strained in Switzerland in the

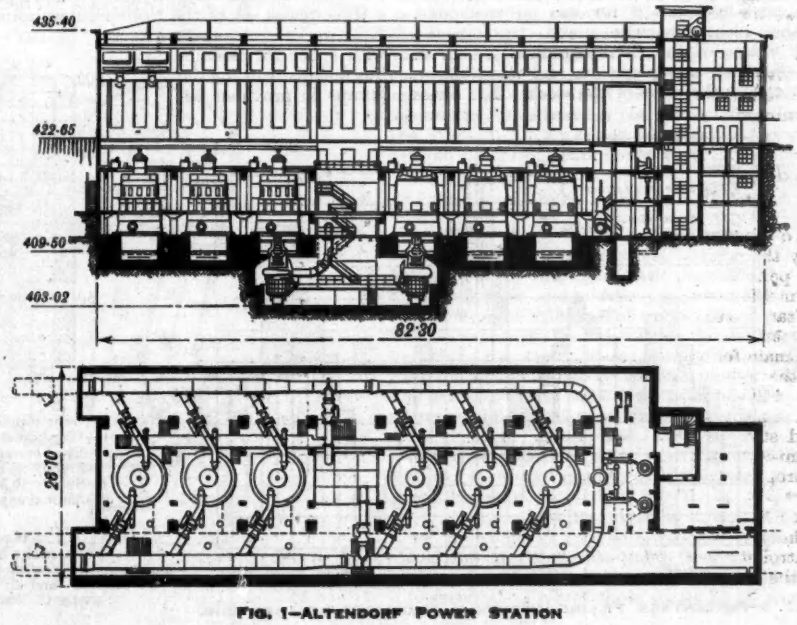


FIG. 1—ALTENDORF POWER STATION

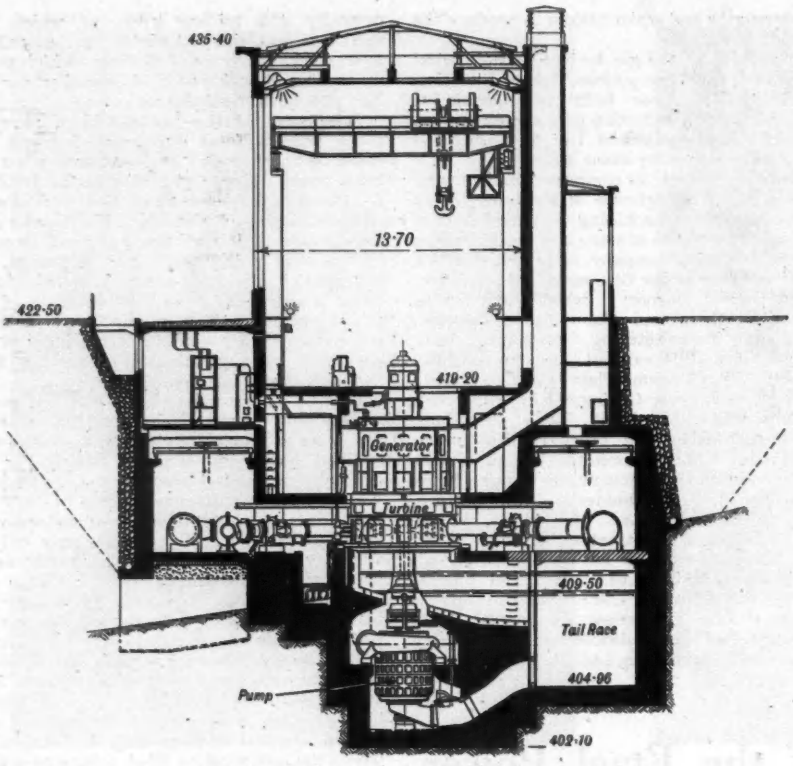


FIG. 2—SECTION THROUGH PUMPING SET

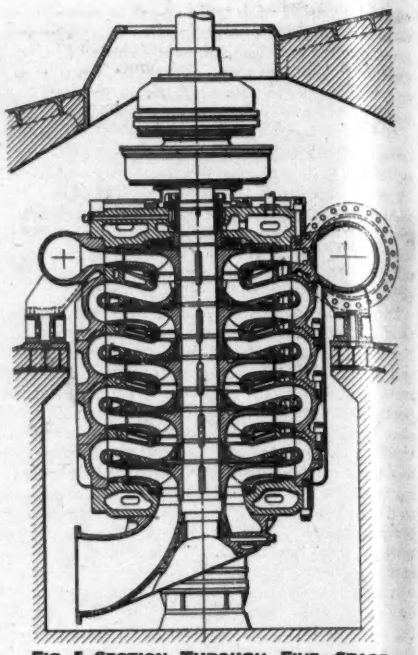


FIG. 5—SECTION THROUGH FIVE-STAGE PUMP

winter of 1949 to 1950, on account of the unusually low water of the rivers. The maintenance of the supply without undesirable restrictions called for the use of all possible expedients, including thermal power generation inside the country and the import of electricity from abroad. Much of the imported current, however, was available only during the night, as during the day the shortage of electricity was also keenly felt abroad. Thus the current imported from Holland was to be had only from 10 p.m. till 6.30 a.m., and on Sundays. Part of this Dutch electricity was used in the Wäggital and Altendorf power stations for driving storage pumps and was thus converted into peak-load power for use on weekdays. Further electricity was stored, through the good offices of the Bernische Kraftwerke, in the Oberhasli power station, and was likewise used during the days of the week. The Swiss Federal Railways, which were also in difficulties, received their share of this imported current. During nights in the week, part of the power generated in the thermal station at Beznau was also used for pumping, in so far as it was not required for the mains of the Nordostschweizerische and Bernische Kraftwerke.

HYDRAULIC POWER STORAGE PUMPS

Figs. 1 and 2 show transverse, longitudinal and horizontal sections through the power station building and illustrate the arrangement of the pumps. One of them is coupled to a single-phase turbo-generator set belonging to the Swiss Federal Railways and the other to a three-phase set of the Nordostschweizerische Kraftwerke. A shaft with space for assembling and dismantling the pumps is provided between the two sets. The pumps had to be chosen to suit the capacity of the generators already installed, which was 18MVA when run as motors. They were therefore ordered with a nominal input of 21,450 metric h.p. each at the pump shaft, a discharge head of 1561ft and a delivery of 38,165 gallons per minute, giving an efficiency of 85·6 per cent.

The two pumps were supplied conjointly by Sulzer Brothers and Escher-Wyss, Zurich, and were dimensioned for the working data given in the acpompanying table.

Pump Data

Discharge quantity, g.p.m.	35,525	36,580	38,165
Total discharge head, ft	1,611	1,592	1,561
Speed, r.p.m.	—	500	—
Efficiency, per cent	86	86	85·6
Input, h.p.	20,500	20,880	21,450
Motor rating, h.p.	—	23,500	—

Fig. 5 shows a longitudinal section through one of the two pumps. The designers had to take account of the fact that the pump foundations had been laid at the time when the Altendorf power station was built, more than ten years before the pumps were actually ordered, and had been made with the intention of installing a four-stage pump. Developments in the design of turbo-machines in the interval and the need for the highest possible efficiency led, in the final project, to a five-stage instead of a four-stage unit. As the height of the installation was fixed, this called for special design measures and it was chiefly owing to the solution found for the problem of the coupling that it was possible to install a five-stage pump in the available space. Sulzer Brothers undertook to supply the pumps up to and including the shaft ends

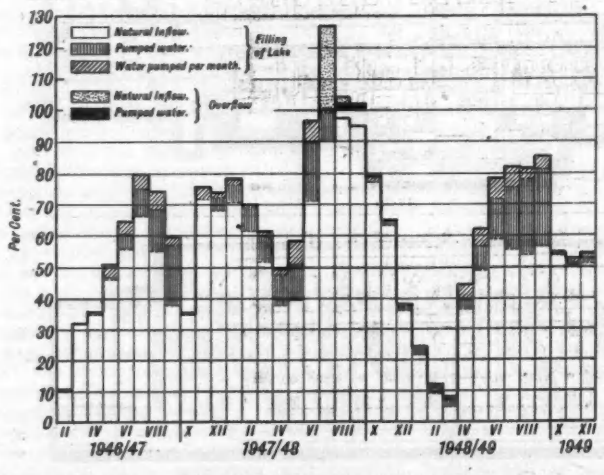
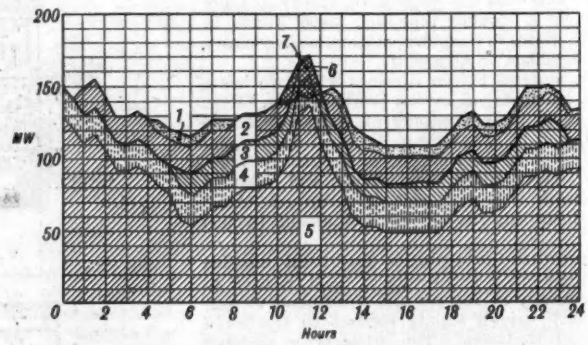


FIG. 3—PERCENTAGE FILLING (MONTHLY AVERAGES) OF LAKE SIHL



Power supplied :
1—Wäggital storage pumps.
2—Etzel storage pumps.
3—Supply to Federal Railways.
4—Supply to Bernische K.W.
5—Normal supply.

Power obtained from outside
6—From Wäggital reservoir.
7—From Löntsch reservoir.

Diagram of load on the mains of the Nordostschweizerische Kraftwerke A.G. on Sunday, June 5, 1949, illustrating the surplus power available on Sundays in summer and its utilisation.

FIG. 4—MAINS LOAD DIAGRAM

for the drive, while Escher-Wyss supplied the intermediate shafting for coupling the pumps to the existing turbines, the step bearings, the disconnectable couplings, the connecting piping and the spherical seating valves.

The outside diameter of the pumps was rendered somewhat smaller than in the original project by the provision of five instead of four

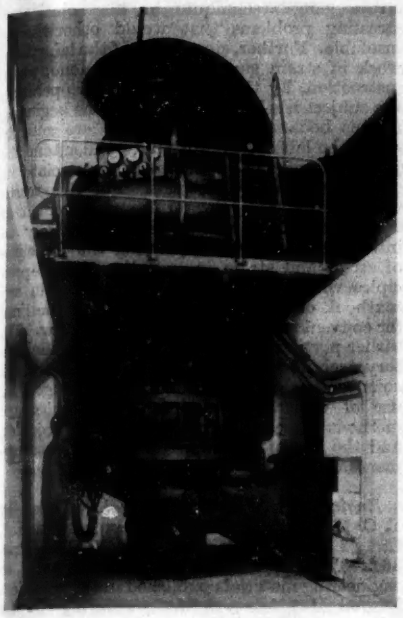


FIG. 6—FIVE-STAGE PUMP

stages, which called for a minor modification of the foundation. As shown on Fig. 1, the pumps can be assembled and dismantled through the central shaft, while they are pushed below their turbines from the pump floor on permanently fitted rollers (Fig. 5).

The five-stage storage pumps, one of which is shown in Fig. 6, are remarkable in that very few pumps—or spiral turbines—of this size have been built for a working pressure of over 1600ft water column. For this reason, among others, the construction of the volute casing and of the cover called for new designs, no previous experience being available.

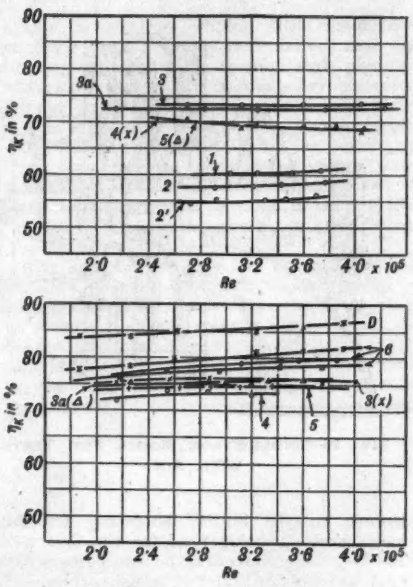
In order to ensure a sound casting, the form of the volute casing, which is provided with the usual ribs, was made as simple as possible. Local concentrations of material had to be avoided and the designing office therefore decided to weld the first cross-over piece to the volute casing instead of bolting it on. This procedure dispensed with the whole mass of the bottom connecting flange and about 8in was thus saved on the height of the machine. The joint was made with a double circumferential weld, care being taken to see that the welds themselves would be subjected to pure tensile stressing only. The space between the two circumferential welds was used for a hydraulic pressure test, so that it was possible to test the tightness and strength of the first tack weld. This examination proved that the weld was a complete success.

The purchasers demanded very strict guarantees with regard to the wear of the parts of the pump coming in contact with the water, which were therefore made of specially resistant materials. A further problem was presented by the covers, which have not only to take the total pressure but also to remain watertight. A step bearing for an axial load of about 100 tons is fitted on the top of the pump and serves at the same time as a radial guide bearing. Among other components the shut-off valves provided before the suction inlets may be mentioned. These valves are open during service and are closed only during overhauls.

The coupling between turbine and pump raised a problem of its own, as there could be no question of allowing the pump to run with the turbine when empty on account of the high ventilation losses. There were several possibilities for the design of this coupling, but the choice was restricted by the local conditions. Electromagnetic and hydraulic couplings, the latter, for instance, as designed by Föttinger, can be operated during service, but were considered very bulky, complicated and expensive. In view of the restricted space and in the interests of simplicity, it was decided not to use a coupling intended for engaging and disengaging during operation, but to fit a friction clutch, which could be engaged and disengaged only with the pump out of operation. This clutch is effective in one direction of rotation only, but is then free of slippage. It was supplied by Escher-Wyss. It can be remote-controlled from the machine hall and is remarkable for its small size.

As already stated, it was only the extremely compact design of this clutch which enabled a five-stage pump to be accommodated in the available space. The transmission elements consist of tangential spokes resting on the clutch hub and the friction shoes. These shoes come up against the outer shell of the clutch, which is connected to the lower half by axial teeth. The purpose of the teeth is to permit any longitudinal displacement of the shaft to be taken up, so that the clutch proper is unaffected by this. An intermediate shaft is fitted between the clutch and the coupling flange of the Pelton turbine.

The hydraulic shut-off means between the pump and the discharge pipe is a double spherical seating valve consisting of a service valve and an isolating valve. The service valve is fitted with hydraulic drive, while the isolating valve is hand-operated. The inlet branch of the service valve also serves as a Venturi meter. The valve itself is designed to close automatically as soon as the speed falls below the limit of 300 r.p.m. or whenever a serious drop in pressure occurs in the pipe.



Top: Measurements without turbulence grid.
Bottom: Measurements with turbulence grid.

1—Model 1.
2—Model 2, rounded edges.
2'—Model 2, sharp edges.
3—Model 3.
3a—Model 3a.
4—Model 4.
5—Model 5.
6—Model 6.
D—Diffuser only.

Efficiencies of various model designs for the Etzel storage pumps as a function of the Reynolds number.

FIG. 8—EFFICIENCIES OF MODEL DESIGNS

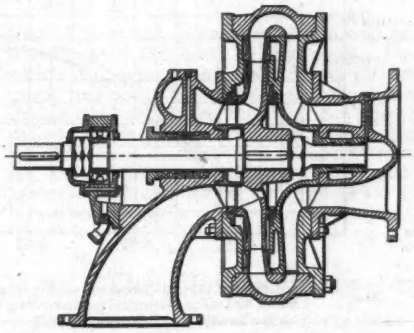


FIG. 9—SINGLE-STAGE MODEL FOR TESTS WITH WATER

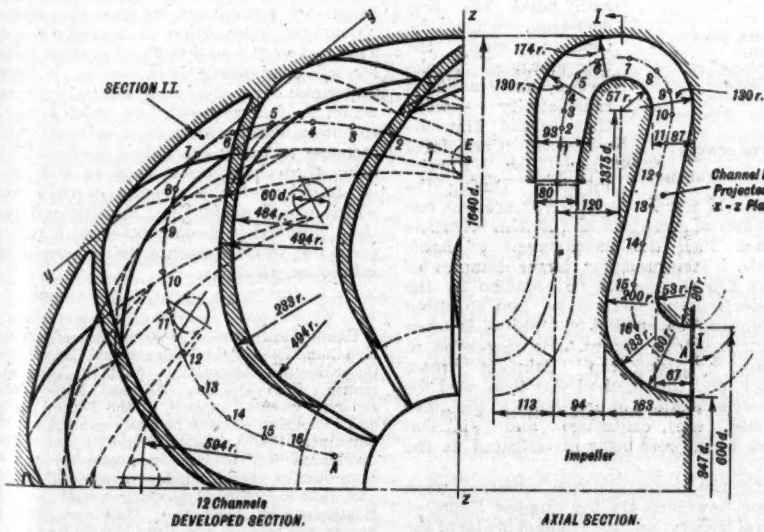


FIG. 7—SINGLE-STAGE MODEL DESIGN

INVESTIGATIONS INTO FLOW AND ACCEPTANCE TESTS

The restricted height also called for specially designed guide and cross-over elements. As no satisfactory data were available on the construction of machines of this size, and since it was impossible to submit the finished sets to tests in the works, it was decided to investigate the questions by systematic model tests. The shaping of diffusers, cross-over pieces and return channels was investigated in this way: a single-stage model was carried out and measurements made with it; and finally various investigations were conducted into strength properties.

Fig. 7 shows the development of one of the forms investigated for the cross-over channel. While the height of the pump was fixed, no increase in the total losses was acceptable on this account. Five of these forms in all were

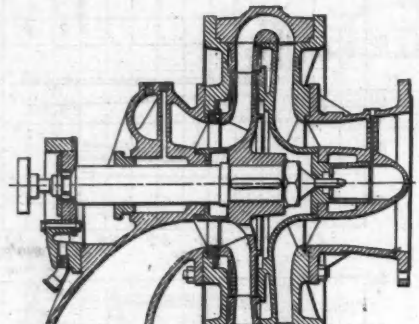
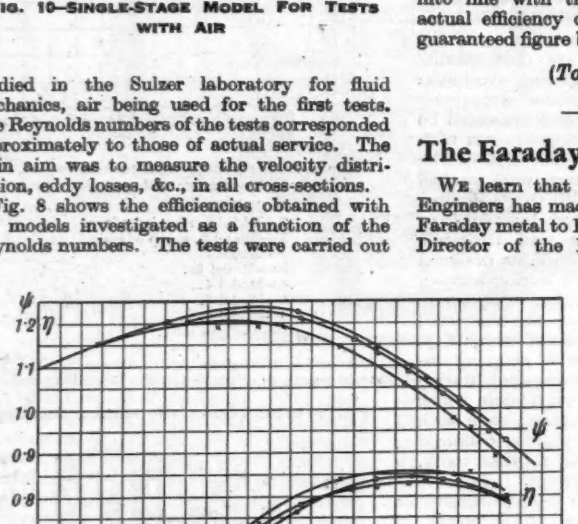


FIG. 10—SINGLE-STAGE MODEL FOR TESTS WITH AIR

studied in the Sulzer laboratory for fluid mechanics, air being used for the first tests. The Reynolds numbers of the tests corresponded approximately to those of actual service. The main aim was to measure the velocity distribution, eddy losses, &c., in all cross-sections.

Fig. 8 shows the efficiencies obtained with the models investigated as a function of the Reynolds numbers. The tests were carried out with and without a turbulence grid. It is clear from the results that the turbulence grid permitted a definite improvement to be obtained.



Efficiencies and pressure coefficients obtained with water and air in the model pumps shown in Figs. 9 and 10, on the basis of the following formulæ :—

× Water Re = 24 . 10^6.
O Water Re = 12 . 10^6.
□ Air Re = 3·4 . 10^6.

φ = non-dimensional volume.
ψ = non-dimensional pressure coefficient.
η = efficiency.

For air : $\eta_A = \frac{N_{adia}}{N_{shaft}}$

For water : $\eta_W = \frac{N_{mano}}{N_{shaft}}$

For air : $\psi = \frac{2g \cdot H_{adia}}{U^2_2}$

For water : $\psi = \frac{2g \cdot H_{mano}}{U^2_2}$

$\varphi = \frac{V}{(\pi D^2_2/4) U_2}$

N = horse power.
H = head.
U = velocity.
V = volume.
D = diameter.

FIG. 11—EFFICIENCIES AND PRESSURE COEFFICIENTS FROM MODEL TESTS

In the light of the results of the channel tests, a single-stage model pump was constructed and was submitted to detailed measurements on the test bed, both with water and with air. Figs. 9 and 10 show the set-up of the test pump during these two series of tests, which were conducted with different Reynolds numbers. The degree of correspondence in the results of the tests carried out with the two media, as plotted in Fig. 11, is worthy of note. The difference between the test with air at Re = $3 \cdot 4 \times 10^6$ and that with water at Re = 24×10^6 was only a few per cent, the efficiency η increasing, as was expected, with the Reynolds number, while the pressure coefficient ψ diminished.

It is well known that the transference of test results from the model to the actual execution offers certain difficulties even in the case of water turbines. These difficulties are much greater for pumps, as far less experience is here available. Several conversion formulæ are in use, and each of them yields a different result. The conversion system used by Sulzer Brothers indicated an improvement in efficiency, in the actual execution as compared with the model, of 2·5 points Moody's formula indicated 3·5 points and a third formula 3·6. The acceptance tests on site revealed an improvement of 1·5 points only.

These tests, which were carried out in 1948, confirmed the faultless mechanical operation of both sets. The discharge of the first pump was initially slightly too high, but a little additional machining of the impellers at once brought it into line with the guaranteed values. The actual efficiency of 87 per cent exceeded the guaranteed figure by 1 per cent.

(To be continued)

The Faraday Medal of the I.E.E.

We learn that the Institution of Electrical Engineers has made the thirtieth award of the Faraday metal to Professor Ernest O. Lawrence, Director of the Radiation Laboratory, University of California, "for his distinguished work in nuclear physics." Lawrence was born in Canton, South Dakota, educated at the universities of South Dakota, Minnesota, Chicago, and Yale, and became Professor of Physics at the University of California in 1928.

His early researches were concerned with photo-electric effects and in 1930 he became interested in the possibilities of using the method of resonance acceleration to obtain positive ions of very high energies, by arranging a number of consecutive accelerations through relatively low differences of potential. However, his appreciation of the limitations of this method of linear acceleration led him to devise and build the first cyclotron, which he used to study the transmutation of elements and artificial radioactivity — work that earned him the award of the Nobel Prize for Physics in 1939. During the second world war Professor Lawrence was one of the team of American and British scientists concerned with the development of fissile materials. The need for larger samples of uranium 235 than could be obtained by the mass spectrograph method led him to study the large-scale separation of uranium isotopes by electromagnetic means. He succeeded in this task by using the "Calutson" mass separator, and this method was then used for large-scale separation in preference to the other techniques, the centrifuge and diffusion systems, which were being investigated at the time.

Among the many honours conferred upon Professor Lawrence are the Hughes Medal of the Royal Society, and the Duddell Medal of the Physical Society.

Short Notices

Resistance Strain Gauges. By J. Yarnell, B.Sc., A.Inst.P. London: *Electronic Engineering*, 28, Essex Street, Strand, W.C.2. Price 12s. 6d.—This book is concerned particularly with the construction and use of strain gauges. It is intended as an introduction to the subject for the benefit of experimental engineers and designers who may be unfamiliar with the use of strain gauge techniques in the solution of stressing problems that would otherwise be insoluble. Further, since much of the laboratory work in strain gauge methods is done, under instruction, by the less experienced operators, the subject has been treated from the beginning in this book, so that those who are actually doing the laboratory work may understand the principles of the method and appreciate its limitations and possibilities. For this reason the concluding chapter on the measurement of two dimensional strains is preceded by an introductory chapter explaining the principles of stress and strain in two dimensions—principles which can be found elaborated in any textbook on elasticity, but which are outlined for convenience in the book under review. The earlier portion of the book is devoted to laboratory techniques and describes the theory and construction of wire-wound strain gauges, the use of cements, bridge theory, circuits and methods of measuring, indicating and recording, and the use of slip rings for making measurements on rotating machinery.

Engineering Materials Manual. Edited by T. C. Du Mond. London: Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 36s.—This is a collection of manuals on engineering materials published in the American journal *Materials and Methods* during the last few years. Each of the twenty-eight sections into which the volume is divided presents a concise comprehensive description of a material or group of materials of interest to engineers. The wide field covered can best be appreciated by reproducing the following list of the main sections of the book: standard engineering steels; stainless steels—their selection and application; high-strength low-alloy steels; clad steels; tool steels; free-cutting steels; grey iron castings; wrought aluminium alloys; aluminium alloy castings; magnesium alloys; nickel and high-nickel alloys; engineering bronzes; beryllium copper; bearing metals; cemented carbides; ceramics for engineering applications; rubber as an engineering material; a plastics primer for engineers; selection and application of plastics; thermosetting plastics; the thermoplastics; plastic laminates; hard facing materials; organic finishes for metals; electro-plated coatings; colouring of metals; porcelain enamels; and industrial adhesives. Following a general introduction to the subject, each section is carefully subdivided to deal with the different aspects, applications, properties and forms of the materials and many useful tables are reproduced to give the maximum amount of information in a condensed form. This is a very useful work of general reference for all engineering libraries, as it provides under one cover the brief essential information which is often required, but which is not easy to obtain over a wide field of materials without recourse to many specialised books. The one thing that the volume lacks in our opinion, is an index at the opening of each section, which would avoid the necessity and loss of time involved in finding notes on a particular point not obvious from a quick perusal of the subsection headings.

CARGO HANDLING.—At a meeting of the Executive Committee of the International Cargo Handling Co-ordination Association, held in Antwerp last month, the president, Admiral Mark-Wardlaw, reported growing support in the United Kingdom and increasing interest in many countries. It was announced that a meeting would be held in London on March 7th to hear a report by the Chief Co-ordinator on his mission to the United States, and that a technical meeting would be held in Rotterdam on April 21st, 22nd and 23rd, when papers will be read and visits arranged to the ports of Rotterdam and Amsterdam.

Some Research of the South African National Physical Laboratory

(By Our South African Correspondent)

WORK has started at the new Pretoria site of the South African National Physical Laboratory, on the building for a 45in cyclotron. This instrument will be used for studying nuclear reactions and for producing short-lived radio-active isotopes which cannot be imported and are urgently required for research on medical, biological and agricultural problems. It is considered most suitable for training research students in South Africa in the techniques of modern nuclear physics, and will be available to South African universities for this purpose. This cyclotron will be of approximately the same size as that at the Massachusetts Institute of Technology, U.S.A., but will incorporate recent developments in cyclotron techniques.

Plans for the nuclear physics laboratory have been completed and building operations started. Sliding, water-filled doors, weighing approximately 17 tons each, will separate the laboratories from the cyclotron hall, the floor of which will be 30ft below ground level, so that instruments and staff will not be affected by radiations produced by the cyclotron. The steel core of the magnet will be made from approximately 76 tons of steel, and the 7-ton pole-pieces, 45in in diameter, will be machined to an accuracy of one-thousandth of an inch, to ensure a uniform gap, and a uniform magnetic field, between the poles. The excitation winding of the magnet will consist of hollow-core aluminium wire, in twelve lengths of 235 yards each, with a total weight of 4 tons. Aluminium has been chosen because it is lighter and cheaper than copper, and can be extruded in lengths of 235 yards without welding.

Spectrochemistry.—Research on the development of spectrographic techniques is undertaken in the South African National Physical Laboratory, which has very well-equipped spectrochemical laboratories. The equipment includes light sources such as d.c. and a.c. arcs, as well as high-energy and high-tension sparks. The most complex spectra can be photographed with a large or medium Hilger spectrograph or a Jarrel Ash grating, while weak Raman radiation can be photographed with a high-intensity Steinheil spectrograph. There are three microphotometers for measuring the intensity of spectral lines recorded on photographic plates and calculating boards, using Siedel functions, for making final calculations. With this equipment, the most varied samples can be analysed with speed and accuracy.

Spectrochemical techniques have been developed and applied to a number of industrial problems in the laboratory, including analyses of printers' metals, and battery lead, determination of magnesium in iron castings, and analyses of uranium ores. Spectrochemical analyses are especially suitable for determining so-called "trace" elements in soils, deficiencies in which are found to be responsible for physiological disorders in plants and animals.

The role of trace elements in soil fertility and in plant and animal metabolism is receiving increasing attention among biological and agricultural research workers. In South Africa certain plant diseases have been attributed to deficiencies of zinc, copper, boron, iron, magnesium and manganese, while it has been shown that excesses of manganese in other soils have a toxic effect on fruit trees. Sheep diseases in some regions have been found to be due to deficiencies of copper. It is also suspected that deficiencies of cobalt, molybdenum and nickel, and excesses of barium, selenium and chromium may be responsible for physiological conditions encountered in plants and animals in certain areas. It has been found that this research on trace-element problems is being held up due to a shortage of staff and of equipment, and the laboratory has offered to assist by undertaking spectrochemical analyses on behalf of biological and agricultural research workers. The main objects of this work are to ensure that data are systematically collected so as to form the basis of a survey of biologically significant trace-elements in South African soils.

Photo-Elasticity.—The South African National Physical Laboratory is developing photo-elasticity apparatus and using it to study strains in the walls of houses, caused by movements of the foundations. This work is closely linked with investigations by the National Building Research Institute, in which strain-gauge equipment is used to measure the strains in experimental walls which are supported either at the ends or at the centre. This research aims at finding the most economical methods of reinforcing brickwork so as to prevent walls from cracking when they are subjected to vertical forces caused by the swelling of clay foundations.

Aeronautical Research.—The C.S.I.R. Committee on Aeronautical Research and Information, which is closely linked with the Commonwealth Advisory Aeronautical Research Council, has co-ordinators who keep in touch with developments in eight different fields of aeronautical research in other Commonwealth countries. In South Africa a study programme has been started in connection with the incidence of high-velocity air gusts on commercial air routes, and the nature of the gusts encountered in clear air at high altitudes, i.e., 30,000ft and upwards.

This research is being undertaken by the National Physical Laboratory. Orders have been placed for eight *V.g* recorders, which are small, lightweight units for recording graphically the vertical acceleration experienced by aircraft, together with the velocity of aircraft at the time of the occurrence of the acceleration. In addition, a prototype instrument is under trial which will record, photographically, the velocity and the vertical acceleration in relation to time.

Records obtained with these instruments will give information on the maximum strains to which the aircraft are subjected; the relative smoothness of different airways routes, and the magnitude of vertical velocities at different places and at different altitudes. This information will be of immediate use to aircraft operators in the Union, and will also give aircraft designers assistance in assessing factors of safety to be allowed in the construction of airframes.

Aircraft Hydraulic Power Pack

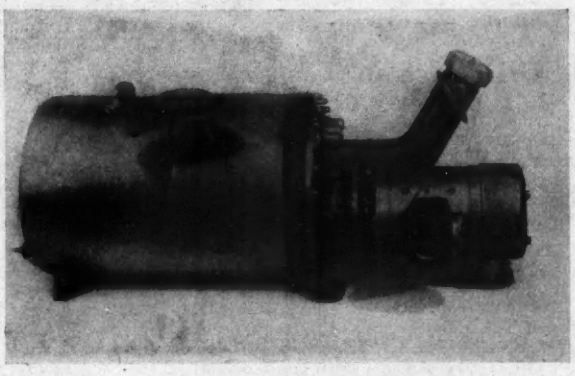
THE unit illustrated herewith is a self-contained hydraulic power pack consisting of a radial pump direct coupled to a 5 h.p. variable-speed B.T.H. motor and weighing only 45lb (dry). It is made by Dowty Equipment, Ltd., Cheltenham, for use in aircraft and is being fitted to the "Princess" flying boat and the "Ambassador" aircraft.

The pump delivers 0·43 gallon per 1000 r.p.m. at zero pressure, and will develop normal working pressures ranging from 2000 lb to 2800 lb per square inch. Normal speeds range from 4500 to 6250 r.p.m. with a maximum of 7000 r.p.m. under no load conditions. At maximum speed and pressure the pump achieves an overall efficiency of 80 per cent.

The unit is shown together with its reservoir of 33 pints capacity, the overall dimensions being only 29½in by 10½in by 12in. Installation and maintenance are relatively simple. Idle running of the pump is eliminated because of the automatic control of the motor through a separate pressure-operated switch.

Our illustration shows the direct-drive coupling of the pump and motor, and the housing of the filter, pump and pipe-line assemblies in the aluminium alloy reservoir. By the detachment of the reservoir end plate, which is secured over studs, the complete pump and motor assembly can be withdrawn from the reservoir body; the pump itself is attached to the plate by three studs. A separate connection is provided in the installation for coupling to an emergency hand pump, if required.

The light alloy casing and cover are bolted together to house a camshaft, which is sealed by twin sealing rings and rotates on roller bearings to reciprocate three equally disposed pistons. Reciprocation of the pistons is effected by their individual connection to a slipper which rides on the bush and needle bearings of the cam. Spacers are fitted between the slippers, and both slippers and spacers are held in continual contact with the bush by two rings. Each piston is located in a sleeve, drilled for fluid ports, and with the uncovering of these ports during the inlet stroke fluid is drawn into the cylinder above the piston head. On the compression stroke the inlet ports are again covered and the fluid above the piston is forced past a spring-loaded disc valve via drillings to the outlet connection.



HYDRAULIC POWER PACK

The Flying Boat

THE relative neglect of the flying boat in this country was again emphasised in the course of the Tenth Brancker Memorial Lecture, read before the Institute of Transport on Monday, February 11th. The lecture, entitled "The Flying Boat and its Place in Aviation," was given by Air Chief Marshal Sir Frederick Bowhill, Chief Aeronautical Adviser to the Ministry of Civil Aviation. It stressed the advantages inherent in the flying boat when factors such as landing areas and landing gears were examined. Sir Frederick maintained that future flying boats would be even larger than the "Princess" and that their bases should be equipped in the manner of ships and their sites restricted to the larger ports.

In a historical review, Sir Frederick referred to that other occasion in the development of the flying boat when, in 1932, work on the 35-ton six-engined Supermarine monoplane boat was abandoned because of the economic circumstances which prevailed.

There were, the paper continued, three main arguments used by the antagonists of the flying boat: the supposed uneconomic nature of the vehicle and the burden of parallel organisations were two objections which no longer existed under present air traffic conditions, when the latest flying boats now developed were compared with high-speed landplanes. Dealing with the third argument, that of the cost of marine bases, Sir Frederick maintained that, with the assistance of experts of the Ministry of Civil Aviation, he had come to the "honest" conclusion from a complex analysis that the marine base was cheaper than

an aerodrome, particularly when the larger machines were considered. He suggested that flying boats would use bays formed by pontoons for docking purposes, and he showed that damage by floating debris during landing was very rare.

Flying boats using river estuaries would alleviate the landing noise factor, which was becoming a serious problem with aerodromes, and he instanced the fact that every twenty minutes, in houses within one or two miles of London Airport conversation with windows open was apt to be impossible.

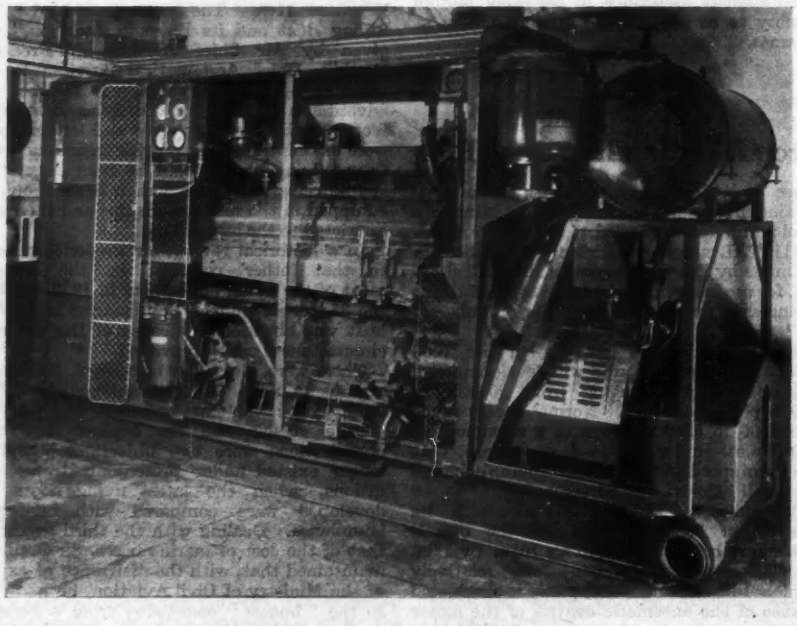
Another important advantage of the flying boat mentioned in the paper was its safety factor. As a former Commander-in-Chief, Coastal Command, he was aware of many landings and even take-offs by flying boats in "appalling" conditions out in the Atlantic. Sir Frederick concluded by hoping that this country would not allow its flying boat designers to be scattered before realising the worth of such machines.

Oil Search in Tunisia

CLOSE to the small Arab village of Zeramedine, about 45km south of Sousse, Royal Dutch Shell, in association with the Societe de Recherche et d'Exploitation des Petroles en Tunisie, have been operating a "wild cat" drilling. Known as Zeramedine No. 1, the drilling rig employed is the latest Ideal pattern, manufactured by the Oil Well Engineering Company, Ltd., Stockport, which is capable of reaching a depth of 12,000ft, and is powered by three 400 b.h.p. Paxman "Mark 12 R.P.H." engines. The engine group has been so arranged that the engines can be compounded to drive either the draw-works or a slush pump or both. There are three more 400 b.h.p. "Package" sets in this particular field, each driving slush pumps to ensure that a high rate of mud circulation is maintained.

Drilling is in operation twenty-four hours per day and an outstanding point of the three engine drive group is the short time, four hours, in which an engine can be removed and replaced while the rig is still in operation. This is made possible by the use of the self-contained Paxman "Package" set, which we illustrate and which includes engine, radiator, fluid coupling, air coolers, fuel tanks, &c., all mounted on a fabricated underbase of skid design. Each set is connected independently by the "busbar" system to the fuel oil lubricating oil and cooling water supply lines and to the compressed air supply for use with the air starter motors on each unit.

Of particular note are the safety devices which are fitted to the engines in order to protect them from damage should there be a serious drop in lubricating oil pressure or an undue rise in the temperature of the cooling water. In the event of such a situation occurring the engine is automatically isolated from the drive group by a device which ensures the withdrawal of the scoop in the fluid coupling. At the same time the working oil circuit of the governor is drained so that the fuel racks move to the closed position and the engine is shut down. Another danger is the release of a large quantity of natural gas, which could enter the air inlet so that the engine would not be under governor control. To obviate this possibility a protective device has been installed and this consists of a butterfly flap valve, fitted in each air inlet manifold, the closing of the valves preventing any natural gas from entering the system. Although severe cold is unlikely to occur in the climatic conditions obtaining in Tunisia, each set is equipped with electrical heater elements to warm the lubricating oil and cooling water to ensure easy starting from cold should the occasion arise.



400 H.P. SKID MOUNTED "PACKAGE" SET

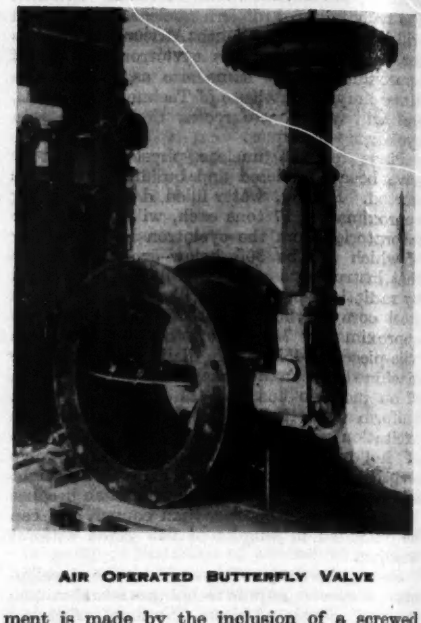
Pneumatically Operated Butterfly Valves

WE illustrate herewith one of a range of pneumatically operated butterfly valves which is now being made in this country by the Fisher Governor Company, Ltd., of Century Works, London, S.E.13. These valves are particularly intended for use in automatic systems for the control of liquids and gases under relatively low static pressures and are made in sizes varying from 4in to 24in.

The discs of the valves are strengthened by ribs and are shaped to offer the minimum resistance to flow in a pipe-line. The maker states that when a valve is closed the clearance between the disc and bore of the body does not exceed 0·5 per cent of the total pipe area. The valves are made either in steel or cast iron, and in the case of the larger sizes fabricated construction is largely used.

The disc is connected to an air-operated diaphragm in the topwork through a substantial crank and lever mechanism fitted with ground pins to reduce lost motion and ensure free controlled turning of the disc. The operating gear in the topwork consists essentially of a thick diaphragm of reinforced synthetic material firmly supported round its circumference between two dished casings of a high tensile iron. The chamber formed above the diaphragm is connected to the operating air supply. A platform kept in alignment by guides is held by pressure of a calibrated spring against the lower surface of the diaphragm. It will be appreciated that movements of the diaphragm through the admission or release of air in the top chamber will be followed by the spring loaded platform.

The platform is connected to a downwards projecting diaphragm rod, which operates the crank of the valve disc. Provision for adjustment is made by the inclusion of a screwed coupling in the diaphragm rod. A pointer is fitted to an extension of the valve disc spindle and, in conjunction with a graduated scale fixed in the topwork support bracket, indicates the degree of valve opening.



AIR OPERATED BUTTERFLY VALVE

If required, these valves can be readily fitted with the makers' "Positrol" automatic positioner, which gives rapid and accurate valve settings for conditions as dictated by impulses transmitted from a primary controller. In this instrument the air pressure from the primary controller is received in a bellows assembly and the pressure is balanced by a spring under compression. The loading of the spring to balance the pressure of air in the bellows is effected through a compound lever system from the spindle of the valve. The admission or release of air to the bellows system reacts on the supply to the diaphragm chamber until it is balanced by the load imparted to the balance spring through movement of the valve disc spindle.

Another instrument which can be used with the valves is the "Wizard" pilot unit for accurate automatic pressure regulation in the delivery side of the main supply line fed through a diaphragm disc valve. These units can be fitted on the top diaphragm casing and are used where frequent and rapid changes occur in the delivery system. They are based upon air pressure pilot actuation, controlled through a connection to the delivery side of the main supply line. Variations in the pressure of the medium delivered through the disc valve are transmitted to the instrument to increase or decrease the supply of air to the diaphragm chamber through a fixed and a variable orifice.

VARIABLE PITCH PROPELLER.—A range of manually operated variable pitch propellers, suitable for small craft, has been developed by Slack and Parr (Marine), Ltd., of Kegworth, Derby. Two and three-bladed propellers are available and are suitable for powers ranging from 30 b.h.p. at 1200 r.p.m. to 200 b.h.p. at 500 r.p.m.

Society of Naval Architects and Marine Engineers

ANNUAL MEETING IN NEW YORK CITY

(By our American Correspondent)

THE fifty-ninth annual meeting of the Society of Naval Architects and Marine Engineers took place at the Waldorf-Astoria Hotel in New York City during November. The general disapproval by the engineering profession of the Government's material allocation policies was strongly expressed in the presidential address to the Society by Mr. J. H. King, vice-president of the Babcock and Wilcox Company, who pointed out that, despite the considerable increase in the size of the American Merchant Navy in the last year, it remains unbalanced, and has too many slow ships, that cannot meet present-day requirements. It was Mr. King's contention that the United States needed more high-speed cargo vessels, more fast tankers and more passenger ships, and that the international situation demanded that such vessels be authorised and constructed without further delay. He expressed concern at the lack of action in America on maritime matters, and said that history was replete with evidence of the necessity for a strong Navy backed up by a strong Merchant Navy for national defence; but, he contended, that fact either was unknown or unappreciated by those in the Government who are charged with the responsibility to provide the materials needed to build ships. The hostilities in Korea and other international activities, he conceded, had brought about some dislocations of economy and material difficulties, but he insisted merchant ships should be more highly rated in priority systems. "It is difficult to understand the mental calisthenics of the minds that can reach the fallacious conclusion that merchant ships are not defence items and therefore do not have defence priority on material," Mr. King asserted. While he noted a large increase in the volume of orders for merchant vessels in the United States, both at coastal and in Great Lakes shipyards, he felt that the outlook for the "profession" in the coming year was not too bright.

Marine Gas Turbine Plant in 1951

Of the nine papers which were presented at this year's meeting, particular interest attaches to a paper constituting an excellent review of the applicability of gas turbine power plants to marine propulsion. Entitled "The Marine Gas Turbine Plant in 1951," the paper was presented by Commander W. T. Sawyer, U.S.N., assistant head of the turbine and gear branch at the Bureau of Ships, Washington, D.C., and also reviews in some detail the four gas turbine engines which have seen service afloat to date in six installations: the simple-cycle 2500 h.p. "Gatric" engine, the simple-cycle 120 h.p. "Rover" units, the simple-cycle 160 h.p. "Boeing" power plant developed for the U.S. Navy, and the 1200 h.p. recuperative "B.T.H." engine which was recently installed as part of the propulsion plant of the tanker "Auris" of the Anglo-Saxon Petroleum Company.

In an initial discussion of the applicability to ship propulsion of the gas turbine the author lists the requirements of a marine propulsion plant as (1) maximum reliability, (2) minimum operating fuel cost, (3) minimum first cost, (4) minimum maintenance and operating personnel cost, (5) maximum manœuvrability, (6) minimum weight, and (7) minimum volume. With regard to reliability, he feels that were the marine gas turbine plant to have a free choice of fuels, it might be stated fairly that its reliability is equal to that of its steam or diesel competitors. This statement is based in part upon the performance, in more than 15,000 hours of revenue service, of a 3500kW gas turbine plant at the Belle Isle Station of the Oklahoma Gas and Electric Company. Furthermore, bunker C fuel, with some attention given to source, has been burned during very extensive operation of the Alco-G.E. gas turbine engined locomotive in 100,000 miles of revenue service on the Union Pacific Railroad during the past two years, and it will be recalled that the power plant of this locomotive is the same basic engine as that in the Belle Isle power station. Thus, evidence accumulated from actual service justifies the statement that reliability of simple-cycle, long-life gas turbine engines of about 18 per cent efficiency has been established as the equal of that of steam or diesel power for operation of the kind required in merchant ship propulsion when supplied with diesel or selected residual fuel oil. Persuasive but somewhat less conclusive evidence to the same effect has been accumulated with more complex recuperative intercooled gas turbine engines of thermal efficiencies up to 26·5 per cent, such as the 10,000kW Brown Boveri unit at the Santa Rosa station in Lima, Peru.

A comparison of fuel costs of gas turbine versus steam and diesel plants involves the consideration of the specific fuel consumption and the type of fuel used. The characteristics of the average merchant ship operating schedule are such that consideration of fractional load operation of the propulsion plant is unnecessary and the full-power comparison is decisive. Modern steam propulsion plants of 12,500–16,000 s.h.p. have shown a fuel consumption (bunker C fuel) of about 0·50 lb per s.h.p.-hour. The specific fuel rate, by test, of a recuperative 1200 h.p. gas turbine propulsion plant now installed aboard ship, is 0·66 lb. per s.h.p.-hour. Since, however, similar stationary plants of higher (2500–13,500 h.p.) powers have shown in service fuel rates from 0·63 lb to 0·48 lb per s.h.p.-hour, the value of 0·55 lb per s.h.p. hour will be taken as the established value for a comparative present-day 12,500 h.p. complex-cycle gas turbine plant. The fuel rate for the long-life simple-cycle gas turbine plant in the 12,500 h.p. range is well established at 0·8 lb per s.h.p.-hour, while a representative figure for modern marine diesel engine specific fuel consumption is considered to be 0·36 lb per s.h.p.-hour.

Insufficient information is available to draw firm conclusions regarding comparative first costs of the different prime movers as adapted to marine propulsion service. Only for the field of electric power generation have sufficient gas turbine plants been delivered to permit even an approach to the establishment of production costs as distinct from single-unit development costs. Inquiries to a leading American manufacturer of both land steam turbine generator equipment and complete gas turbine engine generator units, and to a leading firm of commercial engineering consultants, established the following approximate costs for land prime movers:—

	Cost per h.p., dollars
5000 h.p. simple-cycle, variable-speed gas turbine engine	70
5000 h.p. recuperative, variable-speed gas turbine engine	90
7000 h.p. recuperative, intercooled gas turbine engine	110
17,000 h.p. recuperative, constant-speed gas turbine engine	77
5000 h.p. steam boiler turbine plant	85
5000 h.p. diesel plant	110

The exact comparison of propulsion plant first cost requires, of course, consideration of cost differentials of other machinery required to transmit the power developed to the propeller at the proper speed and direction of rotation and to furnish essential shipboard services in conjunction with the main plant. This is a rather complex undertaking, since many alternatives present themselves. Since no actual installation of the type which permits conclusive comparison has yet been made, consideration of this point will be limited to reference to the factors involved. Reduction of gas turbine plant output rotational speed to that required for either a fixed or variable-pitch propeller may be adopted, either alternative at an increase in cost and a reduction in reliability. The reversible epicyclic reduction gear proposed by T. W. F. Brown, when and if developed and proved, will probably be at least as expensive as the astern elements of the steam plant plus its conventional reduction gear. The non-propulsive power requirements of the gas turbine-engined merchant ship may be met by the use of a separate auxiliary steam boiler serving steam auxiliaries or by the use of auxiliary gas turbo-alternators supplying all-electric auxiliaries. The first cost of gas turbo-alternators will undoubtedly be greater than that of steam turbo-alternators supplied with steam from the main boilers, but other economic aspects of operation may outweigh this unfavourable aspect.

A comparison of maintenance and operating costs, with direct reference to marine plants, is impossible, although very valuable information on the gas turbine plant in this regard will be obtained by the British in the near future. A useful comparison may be obtained, however, by consideration of reports of operating experience in other fields modified to reflect obvious differences in fuel, equipment and load characteristics. Long-life gas turbine plant operating experience has been obtained in three major fields: electric power generation, locomotive service and pipe-line pumping. The commendably detailed report of operation of the 3500kW simple-cycle gas turbo-generator at the Belle Isle station represents the best available evidence of extended operation in this field. With respect to maintenance and operating personnel requirements, the facts established by this plant are not completely applicable to a marine propulsion installation for several reasons. The fuel burned was natural gas; use of either diesel or residual fuel, as required in a marine plant, introduces the possibility of fouling of combustion chambers and turbine, and residual fuel requires preheating. The gas turbine unit itself is a simple-cycle, single-shaft engine, which exhausts through a feed water heater or recuperator used in conjunction with a separate steam turbo-generator installation; marine units will be mechanically more complex, requiring for the simple cycle a power output turbine independent of the compressor drive turbine, and, in the case of the complex cycle, requiring recuperators or intercoolers. No salt water spray entered the compressor, as may well happen aboard ship. No reversing, and only occasional load changes, are required of the stationary plant. With these qualifications in mind, the following report by the chief engineer of the Oklahoma Gas and Electric Company is of considerable significance:—"On May 1, 1951, this General Electric gas turbine has been in operation twenty months. Since this was the first gas turbine installed for continuous service in a central station plant, frequent detailed inspections were made during the first year of service. Each inspection required a shutdown of the unit. Even though this sort of programme was carried out, the unit was on the line for a total of 13,101 hours out of a possible 15,312 hours, or 86 per cent of the time. Since the unit is rated at 3500kW and the average load during the period was 4370kW, the load factor has been 125 per cent. The maximum load carried to date has been 5000kW at 62 deg. Fah. ambient. The unit has made about 135 starts and has never failed to come up to speed and go on the line. The turbine inlet temperature is set at about 1380 deg. Fah. A short inspection was made every twenty-four hours for the first week of operation. The interval was extended to a week, then to ten days and later, to a month. The inspection period now is every 1000 hours. This inspection consists primarily of checking the combustion chamber liners and takes from two to four hours to complete. Little maintenance has been necessary on the unit and all work has been done by regular plant forces. As is standard company practice for new steam

turbines, an overhaul and inspection was scheduled to be done after about six months of operation. In February, 1950, after 3910 hours of operation, the unit was completely dismantled and given a much more thorough inspection than would ordinarily be made. For this work a manufacturer's engineer was secured as a supervisor. The entire turbine-compressor unit was dismantled and closely inspected. 'Zyglo' and 'Magniglow' non-destructive methods of testing were used on important parts, such as nozzles, buckets, compressor blades, and the like. The balance of rotors was checked in dynamic balancing equipment, and the original factory balance was found to be unchanged. All parts, including the combustion chambers, nozzles, and buckets, were in excellent condition and no major items of any nature required replacement. The unit still has the original combustion chamber liners and spark plugs and all indications are that they have many more hours of operation left in them. In the future it is planned to put the unit on the same three-year basis as is used for the steam turbine units. It is likely that the present schedule of six months for minor inspection, requiring three to six days, may be continued."

Experience in the operation of existing gas turbines has shown that its manœuvrability, as regards both unidirectional load variation and starting time, is clearly acceptable for normal marine propulsion service. Marine propulsion, however, requires a reversal of propulsive thrust. Effective transmission systems to permit the gas turbine engine to fulfil this requirement have been demonstrated in actual sea service with gas turbine engines only for very low powers (120 to 160 h.p.), and mechanical reverse gears were used in these instances. The provision of a separate gas turbine for astern power, as is common practice with steam turbines, is thoroughly impracticable. Of the immediately available alternatives, the author favours the use of clutches and a reversing gear with an otherwise conventional reduction gear and fixed blade propeller, or the use of a controllable and reversible-pitch propeller. With regard to manœuvrability, it is impracticable to assign a simple order of relative merit among steam, diesel and gas turbine plants for merchant ship propulsion. When warmed up, all three have established their ability to meet the requirements of normal merchant service. With respect to warming-up time, which appears to be not particularly significant in view of the scheduled nature of operations, the steam plant and high-power diesel plant both require about the same time, of the order of two hours. The simple-cycle gas turbine engine can be started regularly in less than ten minutes, and the complex recuperative engine in less than thirty minutes, without damage or reduction in life.

It will be recalled that, based upon a 3500 h.p. plant designed in 1946 and actually constructed by PAMETRADA in 1950, T. W. F. Brown made a detailed lay-out and weight analysis of a 10,000 s.h.p. gas turbine plant. The author agrees in general with the conclusion that the specific weight of the complex-cycle gas turbine plant installation available to-day is about 10 to 20 per cent lighter than a 600 lb per square inch, 850 deg. Fah. steam installation. An ultimate evaluation of comparative weights of different kinds of machinery requires recognition of their fuel requirements. The proper index of "weight for propulsion" is the specific weight of machinery installation plus fuel, and is a function of the cruising radius. Thus, on the basis of a transatlantic steaming time between fuellings of 250 hours, the total propulsion specific weight, expressed in pounds per shaft horsepower, is 255 for a steam plant, 345 for a diesel engine and 252 for the gas turbine.

A comparison of specific volumes of the three prime movers leads to the following conclusions: the steam, diesel and complex-cycle gas turbine plants require volumes which are not significantly different, and all comfortably fit the volume normally made available as a result of revenue considerations as affected by international tonnage rules. In the event of these tonnage rules undergoing revision, and in certain special service vessels under present rules, the use of simple-cycle gas turbine engines would afford the opportunity for reducing engine-room volume to about the same extent that recent gas turbine-engined locomotives have reduced lengths in comparison to steam or diesel-powered locomotives, that is about 30 to 50 per cent.

From the foregoing considerations of reliability, fuel cost, equipment first cost, maintenance and operating personnel requirements, manœuvrability, specific weight, and specific volume, it appears that limited incentive exists for owners of merchant vessels to consider, at the present time, gas turbine propulsion plants rather than available steam or diesel plants. There is good reason to believe that accumulation of sea experience with a gas turbine plant will produce the missing incentive, for there is ample evidence from other kinds of service to give reasonable assurance of improved reliability, reduced maintenance and operating staff requirements, and improved manœuvrability. Only in specialised applications where machinery weight and space are at a premium and where fuel economy can profitably be subordinated to quick starting, low maintenance, and minimum operating staff, does the simple-cycle gas turbine engine already hold a clear margin of established superiority over its competitors. Uncertainty as to the ability of the gas turbine engine to burn satisfactorily residual fuel oils from whatever source is a deterrent to its marine propulsion application second in importance only to the absence of actual experience in marine service.

With regard to the propulsion of naval vessels, there seems to be little basis for the use of a high-power recuperative gas turbine plant. For the higher powers the relative superiority of the modern naval steam plant over the complex naval gas turbine plant which may be defined by established characteristics of related equipment in related service is based primarily upon the better part-load fuel economy of the former. The percentage power employment schedule of combatant ships, of which the destroyer represents the extreme, establishes a requirement for very good part-load efficiency which can be achieved by the gas turbine plant probably only at the expense of extreme complexity. This same employment schedule also establishes the requirement of long life for only a minor fraction of total power and short life for the remaining major fraction. There is some basis for claim of superiority over steam for a destroyer plant composed of either steam or complex gas turbine plant for base load, and multiple simple gas turbine engines for the major fraction for peak load. The base-load complex-cycle gas turbine engine of this composite arrangement is properly classed with medium-powered engines. In the medium and low-power ranges (less than 10,000 h.p.) the gas turbine engine competes more favourably with the steam plant, but must also face competition from the diesel, which does not enter the picture at high powers. If the uncertainty as to the practical ability of the gas turbine plant to burn widely available U.S. Navy grade special fuel oil were favourably resolved, then its superior military merits would suffice to swing the balance in its favour relative to the low-power steam plant. For powers below about 3000 h.p., where the steam plant drops out of the picture and the diesel engine becomes the primary competitor, the complex-cycle gas turbine plant would now seem qualified for no general application in naval propulsion. In the range of power below about 6000 h.p., however, the simple gas turbine engine occupies the strongest relative position in the entire gas turbine field. There are many classes of short-range craft, both high and low speed, where the lesser combined weight of gas turbine engine and fuel, reduced maintenance and spare parts requirements, and superior compactness make it preferable to-day to the diesel even while both burn distillate fuel. In the author's opinion, it is in this latter power range that the greatest effort should be expended by the U.S. Navy to give the necessary service experience to justify extension of application to higher unit powers and larger vessels.

French Engineering News

(By our French Correspondent)

Experiments are being carried out at Carling with the aim of improving the efficiency in French coking plants, and also, as far as Lorraine is concerned, increasing the quantity of Lorraine coal taken by the coking plants. Until now some 40 per cent of Lorraine coal has been used in these plants. It has been mixed with imported coal, but has not been crushed. It is now hoped that by using a different grade of French coal it will be possible to use more of it.

The new method includes crushing and mixing with coke dust. This is said to reduce the use of imported coal by between 10 and 30 per cent. The methods now being tried out at Carling, however, cannot be introduced into other coking plants until they are equipped with crushing plant. The latest report on the subject states that it would be more economical to include crushers in new or entirely rebuilt plants rather than to try to install them in existing plant. Further, experiments are being carried out which may obviate the use of crushers. For example, at Marienau coal and semi-coke is fed dry to the plant, and this, it has been found, obviates the use of all foreign imported coal and gives a good quality coke.

Although the report is not over-optimistic it is estimated that within a few years the consumption of foreign coal could be reduced, over the whole of the Lorraine area, to between 30 and 35 per cent. This reduction is not considered enough, but until far-reaching changes are made it is difficult to see what more can be done. Considering that before the war the Lorraine mines contributed no more than 2 per cent of their coal for the coking plants, to be used in the steel industry, this is something of an achievement. For, as the report points out, to pass from 2 to 70 per cent is no mean advance.

It is also thought that the Government will be prepared to help the construction of new coking plants in the area. Some 2,400,000 tons of coke were produced in 1951, and it is estimated that this year the production will rise well on the way to the target fixed for 1955, which is 4,200,000 tons. By 1960 it is hoped that the Lorraine area will be able to produce at least 6 million tons.

* * *

Some new rolling stock will be brought into use on the Paris underground railway this month, including the first trains with pneumatic tyres, and in May new articulated trains will be introduced. It will take some years before the whole system will be supplied with the new trains. It is reported that the new trains will be automatically controlled and the driver has simply to start the train, which stops automatically at stations and controls its own speed. If, for example, a train remains in a station for longer than the usual period, the control automatically increases its speed. Train speeds over the lines can be set in advance and increases or decreases in speed controlled automatically according to traffic conditions.

* * *

Prospecting for oil has increased in France over the past few weeks. Such optimistic reports have been reaching the Société Nationale des Petroles d'Aquitaine and the S.N. du Petrole du Languedoc that special efforts are now being made. One company has received permission to prospect in areas covering 818 communes. One reason for this activity is that the first wells worked in France at Pechelbronn are more or less exhausted. In 1939 these wells were producing about 75,000 tons of oil yearly, but this year production has fallen to 56,000 tons.

* * *

A report by Gaz de France shows that in 1951, it was able to provide 3000 million cubic metres of gas, or about 50 per cent more than was used in 1938. The report states that coking plants used some 4,777,000 tons of coal, or 5 per cent, more than in 1950. Altogether, some 2,331 million cubic meters of coal gas was produced for sale, which is a record figure, the total quantity being made up with natural gas.

Industrial and Labour Notes

Coal Production

Coal output in Great Britain last week totalled 4,563,800 tons, of which 4,358,000 tons came from the deep mines and 205,800 tons from opencast workings. Production in the first seven completed weeks of this year has amounted to 30,907,300 tons, compared with 30,328,200 tons in the corresponding period of 1951. The quantity of imported coal which has reached this country since the beginning of the year is 210,000 tons.

The Ministry of Fuel and Power has stated that, in the week ended February 9th, there were 706,500 wage earners on colliery books—nearly 9000 more than a year ago. The number of face workers, 287,900, was, however, only 1100 higher than in February, 1951. The output per manshift at the face in the week ended February 9th was 3·20 tons, the same as that in the corresponding week of last year. Inland coal consumption in the week ended February 9th totalled 4,666,000 tons and distributed stocks amounted to 13,957,000 tons, an improvement of 4,000,000 tons over the stock position in the comparable week of last year.

The Need for Capital Resources

The annual report of Hoover Ltd., which has been circulated this week, contains a statement by the chairman, Sir Charles Colston, which refers, among other matters, to the need for capital resources. One of the most disturbing features of our national economy at the present time, Sir Charles observes, is that an increasing number of important companies are experiencing a growing shortage of capital resources. The considerable rise in prices has necessitated much larger working capital to finance stocks and work in progress.

But of more fundamental importance, Sir Charles goes on to say, is the pressing need to replace the equipment of industry by more modern and more efficient equipment. Otherwise, our place in an increasingly competitive world cannot possibly be maintained. Nevertheless, Sir Charles comments, whenever one of our apparently periodical balance of payment crises occurs, one of the first casualties is the capital investment programme, thereby seriously affecting the possibility of improving our productive capacity. The Chancellor of the Exchequer, Sir Charles points out, announced in his statement at the end of January that home investment was to be cut severely, involving sharp reductions in the supply of urgently required plant and machinery which were needed "in the long-term interest of our economic progress." It may well be, Sir Charles adds, that our external deficit is so menacing that these hard decisions are unavoidable, but the truth remains that failure to keep British industry supplied with the most modern equipment will gravely weaken the national economy.

Trading in Lead

The Ministry of Materials has stated that last week the Chancellor of the Duchy of Lancaster received a deputation from the committee of the London Metal Exchange to discuss the possibility of a return to private trading in lead on the Exchange. Consideration is being given to the views expressed by the deputation.

The Ministry has also announced that, with the agreement of the Canadian and Australian Governments and producers, 30,000 tons of lead supplied under current contracts have been resold and will be delivered to the U.S.A. during the next four months. Prices, the Ministry says, will be equivalent to the current prices for foreign lead in the U.S.A.

Dollar Exports

The Board of Trade recently commissioned an American market research organisation to report on legislation and practice in United States' Federal, state and municipal purchasing. The report has now been published under the title "Dollar Exports: Sales to Public Authorities in the United States," and may be obtained from H.M. Stationery Office at 12s. 6d.

The report notes that, in 1950, the public purchasing organisations in the U.S.A. spent about 15,000 million dollars, and that, up to the present, American manufacturers have been left almost unchallenged in possession of that vast market. Without minimising the difficulties facing an exporter, the survey offers the "reconnaissance report," which can form the basis for a considered investigation by any exporter who is prepared to venture boldly in this comparatively unexplored field, a field in which, it is emphasised, a "positive" approach is of the utmost importance.

The report analyses the field covered by the public purchasing organisations in relation to the United States' market as a whole. The purchasing procedure of the agencies is described, and their general requirements, organisation and location are mentioned. Details are also given of the United States' "Buy American" legislation, which, it is suggested, is not so insuperable a barrier to the foreign exporter as is generally imagined.

Employment and Unemployment

A report by the Ministry of Labour on the employment situation in Great Britain states that during December last the total working population decreased by 74,000, and at the end of that month totalled 23,426,000 (16,007,000 men and 7,419,000 women). The strength of H.M. Forces at the end of December was 852,000, and the total number of people in civil employment was 22,221,000 (14,975,000 men and 7,246,000 women), which total was 123,000 less than that returned a month earlier.

In the country's basic industries 4,074,000 people were employed during December, which figure showed a net loss of 8000 when compared with November. The biggest drop—a seasonal one—was in the total employed in agriculture. In the coal-mining industry the manpower total again rose in December, the number of wage-earners on colliery books being 698,000, compared with 689,000 at the end of 1950. In the manufacturing industries, 8,786,000 people were at work in December, or 48,000 fewer than in November. There was a decline in the labour forces of all the industrial manufacturing groups except "metals, engineering and vehicles," which showed an addition of 10,000, making a total of 4,210,000, compared with 4,092,000 a year earlier. Dealing with other industries, the Ministry's report states that 36,000 fewer people were employed in building and contracting in December and that in "professional, financial and miscellaneous services" there was a drop of 10,000.

The unemployment figures included in the report relate to January 14th, when 378,741 people were registered as out of work, compared with 302,956 on December 10th. The January figure, it is estimated, represented 1·8 per cent of the total number of employees. It included 63,699 who were described as temporarily stopped.

Death Duties and the Family Business

The Association of British Chambers of Commerce has sent to the Chancellor of the Exchequer a memorandum pointing out the damage caused to family businesses by the effect of death duties. The Association expresses its conviction that urgent remedial measures are necessary if consequences disastrous to this essential section of the country's productive resources are to be avoided.

The memorandum emphasises that the family business still has an important part to play. It says that the skill, energy, inventiveness and resource for so long associated with the well managed family concern is an essential element in a balanced economy and should be preserved. The Association claims that there is an increasing volume of evidence to show that the stability of family businesses is being seriously undermined by death duties. The memorandum recommends a substantial lowering of the rates of duty in ranges over £20,000, and suggests that the over-riding principle for determining values on death should in every case be realisable value and that provision should be made for payment of the duty by instalments.

Britain's Overseas Trade

Provisional figures concerning the United Kingdom's trade during January, which were issued by the Board of Trade at the end of last week, showed that exports reached a record value of £250,000,000. Making allowance for an extra working day in January, the total was 6 per cent higher than the monthly average for the second half of last year. Total imports in January continued at a high level, their estimated value being £357,200,000. The value of re-exports is put at £14,200,000, and the excess of imports over exports and re-exports was thus £93,000,000 at the end of January, compared with a monthly average of £109,200,000 in the last six months of 1951.

Exports during January from the United Kingdom to North America, as a whole, have been valued provisionally at £19,400,000, a figure which was below the monthly average for both the fourth quarter of last year and the monthly average for the whole of 1951. Exports to the U.S.A. in January, which have been valued at £10,900,000, were slightly above the average for the fourth quarter of last year. On the other hand, the value of exports to Canada during January was, at £8,500,000, below the average in the fourth quarter of last year.

Engineering Apprentices' Pay

The Confederation of Shipbuilding and Engineering Unions has submitted to the Engineering and Allied Employers' National Federation a claim for an increase of £1 a week on the basic wage rates of apprentices, boys and youths in the engineering industries. It is understood that about 100,000 are affected by the claim in the firms attached to the Employers' Federation. Existing time rates, which are calculated as a percentage of the fitter's rate, range from about £1 9s. a week at the age of fifteen to about £4 a week at the age of twenty.

Nickel Production

Dr. J. F. Thompson, president of the International Nickel Company of Canada, Ltd., has stated in a letter to shareholders that the company mined more ore from underground during 1951 than in any year in its history. Production of ore from underground last year, the letter says, was 7,780,000 tons, or 2,000,000 tons more than in 1950, and the total amount of ore mined from both underground and surface operations was 11,800,000 tons, compared with 9,849,000 tons in 1950.

Last year, the letter continues, the company operated at maximum capacity. Emergency facilities were installed and put into operation several months ahead of schedule, bringing the company's rate of nickel production to 21,000,000 lb a month. At the same time the company made considerable progress with the underground development programme, which was initiated during the second world war. By the end of next year, the letter indicates, when production from surface operations will be fully replaced, it should be possible to raise 13,000,000 tons of ore a year, or twice as much from underground workings as in any year prior to 1951.

Notes and Memoranda

Air and Water

RHINE-AMSTERDAM CANAL.—A new canal linking the Rhine with the North Sea will be opened by Queen Juliana of the Netherlands on May 21st. Named the Amsterdam-Rhine Canal, the new waterway begins at Tiel and runs direct to Amsterdam and thence via the Ijmuiden sea-locks to the open sea.

STABILISING FINS.—The Cunard passenger-cargo liner, "Media," of 13,345 tons gross, has been fitted with Denny-Brown stabilisers at the yard of John Brown and Co., Ltd., who built the ship in 1947. Trials have been completed and the ship is due to begin her first voyage with the new installation on February 23rd.

"KENYA CASTLE."—The third one-class vessel, constructed for the Union-Castle Line, the "Kenya Castle," has arrived at Southampton from her builders, Harland and Wolff, Ltd. Before sailing in the company's regular service to East African ports on April 4th, the liner will leave Southampton on March 7th for a fourteen days' cruise to Spain, Portugal and North Africa.

CARRIAGE OF DANGEROUS GOODS.—The report of the Departmental Committee on the Carriage of Dangerous Goods and Explosives in Ships was published on February 18th and supersedes the report of the 1930 Committee. The committee under the chairmanship of Dr. H. E. Watts, H.M. Chief Inspector of Explosives, has reviewed the existing rules and the report and appendices set out the committee's recommendations for the packing, stowage and labelling of over 600 dangerous substances and for the carriage of explosives. The new report can be obtained from H.M. Stationery Office or any bookseller, price 15s., or 15s. 7d., post free.

LLOYD'S REGISTER WRECK RETURNS.—Lloyd's Register of Shipping has issued its returns of the merchant ships totally lost or broken up for the quarter ended June 30, 1951. Steamers and motorships totally lost consequent upon casualty amounted to forty-one ships of 44,119 tons gross, including four ships of 8330 tons gross, belonging to Great Britain and Northern Ireland, and seven ships of 5576 tons, owned by other Commonwealth countries. Ships broken up, but not consequent upon casualty, numbered seventy-six steamers and motor-ships of 98,590 tons gross, of which twenty-three ships of 41,557 tons were owned by Great Britain and Northern Ireland and fourteen of 14,793 tons by the Commonwealth countries.

Miscellanea

USKMOUTH POWER STATION.—Our attention has been drawn to the fact that in the "Tabular Summary of Civil Engineering Contracts, 1951," which appeared with our issue of January 25th last, the main contractors for the Uskmouth power station should have been given as John Morgan (Builders), Ltd. This firm is carrying out work on the project to the value of some £6 million.

VEHICLE NAME CHANGE.—All Home and overseas versions of the A.E.C. "Matador" Mark III four-wheeled goods chassis with a 9·6 litre oil engine will be known in the future as the A.E.C. "Mandator" Mark III. The alteration does not apply to the 4×4 tractor, as supplied to the Fighting Services, which will continue to be called the "Matador" four-wheel drive tractor.

DUSTS AND POWDERS IN INDUSTRY.—Three lectures under the general title "Dusts and Powders in Nature and Industry" are to be delivered by Dr. H. Heywood at the Royal Institution, 21, Albemarle Street, London, W.1, on Tuesday evenings, February 26th, March 4th and 11th, at 5.15 p.m. The first lecture will deal with "Occurrence and Properties of Particulate Materials," the titles of the two succeeding lectures being "Relative Motion of Particles and Fluids" and "Industrial Applications of Particle Technology." The fee is 2s. 6d. for each individual lecture or 6s. for the complete course.

EDUCATION FOR MANAGEMENT.—The Civil and Mechanical Engineering Department of the Woolwich Polytechnic, London, S.E.18, has arranged for public lectures on "Education for Management in the U.S.A. and England" to be delivered on Wednesday evening next, February 27th, at 7 p.m. The lecturers will be Sir Thomas Hutton, general manager of the United Kingdom section of the Anglo-American Council on Productivity, and Mr. J. Wilson, B.Sc., M.I.Mech.E., Principal of the Birmingham College of Technology.

"IONOMATIC" WATER-TREATMENT PROCESS.—We have received from the Pulsometer Engineering Company, Ltd., 39, Victoria Street, London, S.W.1, some brief particulars of a process for the clarification of highly polluted waters. An ionisation treatment is employed to accelerate the rate of precipitation of solid and colloidal matter in suspension, thus permitting, it is claimed, a considerable saving in the plant and filters required. In the diagram of this "Ionomatic" treatment which we received, the raw water, with negatively charged impurities, is introduced into a tank with positively charged particles of alumina hydroxide and colloidal silica, negatively charged, to form a precipitation of sludge which is drawn off.

BRITISH-BUILT KESSLER-FAIRLEEDE CRUSHER.—We are informed by the Fairleede Engineering, Ltd., of Chatteris Engineering Works, Chatteris, Cambs, that it is about to begin in this country the production of the Kessler-Fairleede double-impact breaker for reducing stone, gravel, clay, coal, &c. Large numbers of these machines are in use in the United States, where five models are made with capacities varying from 20 to 400 tons per hour producing material from 1¼in minus to 4in minus. In these machines two impellers, each fitted with three bars, throw the incoming material on to sets of steel breaker bars. The fragments produced are projected round the body of the machine to collide with each other, and new material entering the breaker, and reduce to a clean product with a low percentage of dust when required. The machines can be used for primary or secondary crushing.

FRENCH REFINERY.—The extensions to the Shell Berre refinery near Marseilles, which were opened on January 17th, marked a further stage in the oil refinery programme in Western Europe. Costing £8,000,000, the extensions have increased the crude oil throughput to 3,000,000 tons yearly, of which 70 per cent comes from Kuwait, with smaller quantities from Iraq and Venezuela. The increase in productive capacity is due to a new 8000 tons per day distillation unit, which has six fractionating columns, and a modern reforming plant having a daily capacity of 1200 tons. At present a catalytic cracking plant of the Houdry pattern is in operation, but by 1953 this will be replaced by a plant employing the fluid catalytic process. The storage capacity at Berre has been expanded to 500,000 tons and the tanks are supplied by pipe-line from the oil port of Lavéra, some 21 miles distant. Adjoining the refinery, at Rognac, is the world's largest liquid gas filling plant.

OERLIKON GAS TURBINE PROGRESS.—In a review of gas turbine progress published in our issue of January 18th, brief mention was made of the order received by Ateliers de Construction Oerlikon, of Zurich-Oerlikon, Switzerland, for a 730kW auxiliary gas turbine generating plant for the power station of the Compagnie d'Electricité et Gas d'Algerie. That order was received in the early autumn of last year and construction is well in hand. The set will be generally similar in design to the 1000kW experimental gas turbine in the company's works, which has already run more than 7000 hours, on a variety of oil fuels, including very heavy boiler oils. As the fuel will be bunker oil, blade washing equipment for the turbine will be embodied in the design. The generator is a standard Oerlikon machine running at a speed of 1500 r.p.m., while the turbine will run at 5000 r.p.m., with a speed reduction gear between the turbine and generator.

DRAWING OF 1839 LOCOMOTIVE.—We have just received from Fibreglass, Ltd., of Ravenhead, St. Helens, Lancashire, a framed, coloured print of a locomotive "Constructed in 1839 by Messrs. Tayleure and Co." For the decoration of its London Offices, Fibreglass, Ltd., made a collection of prints showing the early days of industries with which it had to do in the present decade. It was found that there was a shortage of prints of railways. An approach was, therefore, made to Vulcan Foundry, Ltd., a firm which is a near neighbour of Fibreglass, Ltd. That firm was founded in 1830 by the French engineer, Tayleur, who was joined for a time by Robert Stephenson, and it was known that it had available some drawings of its earlier manufactures. The particular drawing concerned was selected from several, offered by the firm, because of the elegance of the design and because also it showed how rapidly the locomotive evolved in its first years of development. The original now hangs in the London office of Fibreglass, Ltd., and hand-coloured copies have been presented to some of the firm's friends likely to be interested. Our thanks are due to Fibreglass, Ltd., for a print that now graces our own walls.

FINNART PIPE-LINE.—The pipe-line which connects the oil tanker terminal at Finnart, Loch Long, with the Grangemouth refinery of the Anglo-Iranian Oil Company, Ltd., was given cathodic protection against corrosion when built and the results have proved satisfactory. The cathodic protection of this asphalt-coated, 12in pipe-line was effected by the installation of 340 magnesium anodes placed at intervals and attached to the pipe by wires via junction-box/location posts. Self generated direct current flows from the anodes, through the ground, to supply protection to any metal which may become exposed. Another item of interest concerning the new line has been the use of a radio-active Cobalt isotope, placed in the pipe-line scrapers, which are pumped through the line to remove sludge and deposits. By using geiger counters the progress of the scraper could be readily followed and located when jammed, while manœuvring of the scraper in the traps at each end of the line by valve adjustment has been greatly facilitated.

Personal and Business

MR. R. B. W. BOLLAND has been appointed general manager of Head Wrightson Aluminium, Ltd.

MR. L. E. MASHETER has been appointed technical manager of tyre production by Dunlop, Ltd., Fort Dunlop.

FLEXELLO CASTORS AND WHEELS, Ltd., has opened an additional factory on the Trading Estate, Slough, Bucks.

MR. L. W. MORITZ has been appointed chairman of the board of Fordham Pressings, Ltd., Dudley Road, Wolverhampton.

THE NORDBERG MANUFACTURING COMPANY announces that its London office is being moved this month to 19, Curzon Street, W.1.

TELEFLEX PRODUCTS, Ltd., states that its conveyor division has now been moved to Uphall Road, Ilford, Essex (telephone, Ilford 3117).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., announces that the telephone number of its Cardiff branch has been changed to Cardiff 24716.

BAKELITE, Ltd., states that its Northern sales office has been moved to The Royal Exchange, Manchester, 2 (telephone, Blackfriars 5174).

THE HAWKER SIDDELEY GROUP announces that Mr. Edward H. Jefferson has been appointed Resident Director of Hawker Aircraft (Blackpool), Ltd.

INTERMETRIC PROCESSES, Ltd., is the title of a new company formed to undertake liquid honing. Its address is Darby Road, Coalbrookdale, Shropshire.

DAVIDSON AND CO., Ltd., Belfast, states that its Manchester depot will be moved on March 3rd to 42, Deansgate, Manchester, 3 (telephone, Blackfriars 6218).

THE MARCONI INTERNATIONAL MARINE COMMUNICATION COMPANY, Ltd., announces that Mr. John Keir has been appointed assistant general manager of the Marconi marine companies.

SIR JOHN KENNEDY, M.I.C.E., M.I.E.E., states that he will shortly be severing his connection with the Uganda Electricity Board. Future communications should be sent to Woodstock, Chinthurst Lane, Shalford, near Guildford, Surrey.

ROBERT JENKINS AND CO., Ltd., Wortley Road, Rotherham, states that Mr. S. McGonigal, representative in the Lancashire and Cheshire area, has severed his connection with the company. For the present all matters in that area are being dealt with from the head office.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has received, from the Power Steamship Company, Ltd., an order to build a cargo vessel, of length between perpendiculars 450ft by 64ft beam by 40ft 5in depth and a deadweight of 11,550 tons on a load draught of 27ft. The propelling machinery will consist of a Hawthorn-Doxford oil engine of 6600 b.h.p., to give the ship a speed of 15 knots. The company has also contracted to build a 10,500 tons deadweight cargo ship for the Dover Hill Steamship Company, Ltd. This vessel will have a length between perpendiculars of 435ft by 60ft beam by 39ft 6in depth and a load draught of 26ft 7in. A Kincaid B. and W. diesel engine of 4400 b.h.p. will be fitted to give a speed of 13½ knots.

British Patent Specifications

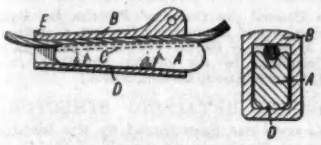
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

WORKSHOP TOOLS AND APPLIANCES

665,020. April 1, 1949.—Devices for Coupling or Securing Ropes, William Herbert Sandford, 60, New Oxford Street, London, W.C.1; and Rupert Evelyn Law Warburton, "The Banks," Frimley Green, near Aldershot, Hampshire. (*Inventor: William Herbert Sandford.*)

Referring to the drawings, the device is shown in a simple form adapted to secure a single rope. The wedge *A* can slide in the socket *B*. One edge of the wedge is provided with a vee groove *C*, while the other edge is substantially flat at *D* to bear directly



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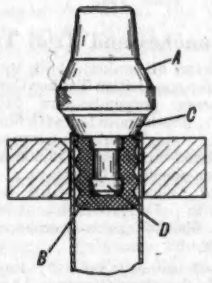
against the wall of the socket. The socket is tapered to correspond with the wedge and may be bell-mouthed at one or both ends as shown at *E*. The rope is inserted between the vee-grooved edge of the wedge and the opposing wall of the socket, so that pull on the rope draws the wedge home. Various modifications in the design for both single and double edges are described in the specification.—*January* 16, 1952.

664,716. June 13, 1949.—Means for Flaring or Expanding the Ends of Tubes, John Millington, 6, The Grove, Great Barr, Birmingham; and Imperial Chemical Industries, Ltd., Imperial Chemical House, Millbank, London, S.W.1.

Referring to the drawing, the drift described comprises a body *A* and a pilot *B*, the body having its upper end shaped to form an anvil head. The lower part of the body comprises a tapered portion *C*, which is the shape of flare or bell required at the end of the tube. Below the tapered portion and integral with the body is an extension *D*, which forms the core of the pilot *B*. Moulded around this extension is a thick rubber coating. The rubber



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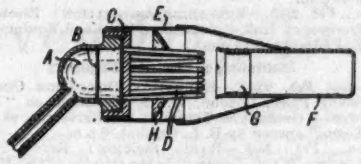
on the outer surface of the pilot is so shaped that it presents a series of annular projecting rings or corrugations. The diameter of the corrugations is slightly greater than the bore diameter of the tube to be expanded. Thus, when the pilot is introduced into the tube it resiliently engages the bore. In operation, a split die is clamped about the end of the tube to be flared, the angle and shape of the die cavity being similar to that of the tapered portion *D*. The drift is placed in position and hammered until the end of the tube conforms to the taper of the drift and the die. The drift and the split die are then removed from the tube and the tube is ready for making a joint. Modified constructions showing detachable pilot portions for the drift are also shown in the specification.—*January* 9, 1952.

664,809. July 5, 1949.—Blowpipe or Blow-torch, Samuel Elgar Ball, 375, Canterbury Street, Gillingham, Kent; and Ernest Thomas Finch, 6, Ladygate Lane, Ruislip, Middlesex.

The invention relates to coal gas blowpipes or blow-torches used for brazing, soldering or pre-heating. Its object is to provide a blowpipe which will operate without the need for a compressed air supply and without sacrificing the efficiency of the flame. As shown in the drawing, the blowpipe comprises three principal members. The first is a gas chamber *A* with a supply tube and a gauze filter *B*. The open end of the gas chamber is attached to the second member, consisting of a tube plate *C*, into which are set the gas tubes *D*. The third member consists of a combined air chamber and flame nozzle. The air chamber is a perforated brass cylin-



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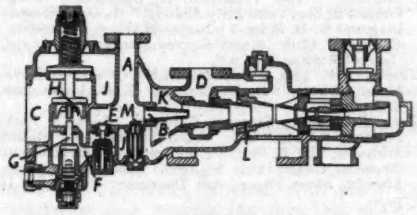
der *E*, which is a sliding fit over the tube plate and is externally fluted. The flame nozzle *F* is slighty bell-mouthed at its inner end and is turned over at the outer end to eliminate the risk of backfire. A sleeve *G* which acts as a compression ring, is located near the inner end of the tube *F* and also serves to deflect the mixture towards the axis of the flame nozzle. The tube and the cylinder are secured together by means of a frusto-conical member and the distance between the end of the nozzle and the jet ends of the gas tubes may be varied by sliding the cylinder over the tube plate. A conical baffle *H* is fitted between the cylinder and the gas tubes.—*January* 9, 1952.

STEAM PLANT

665,588. December 10, 1949.—Exhaust Steam Injectors, Davies and Metcalfe, Ltd., of Injector Works, Romiley, near Manchester (*Inventor: Richard Metcalfe*).

This invention is designed to provide simple and efficient means for enabling the injector to function satisfactorily should the pressure of the auxiliary live steam for operating the injector fall below a certain value. In the drawing *A* is the live steam inlet of the injector supplying the live steam nozzle *B*, *C* is the exhaust steam inlet and *D* the water inlet. *E* is a choke valve which allows live steam to pass from the steam branch *A* via the space *F*, the



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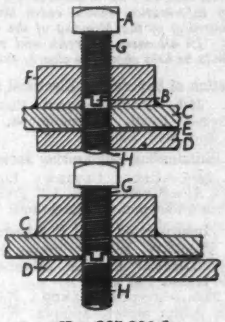
annular space around a valve stem *G*, and the chambers *H* and *J* to the injector cones *K* and *L*. *M* is a second choke valve provided in accordance with the invention to introduce a secondary supply of live steam to the space leading to the injector cones *K* and *L*. This second choke valve *M* is held on its seat against the pressure of the spring by the steam pressure in the branch *A* until this pressure falls below a predetermined value (say, 90 lb per square inch) when the valve opens and admits a second supply of live steam to the injector.—*January* 23, 1952.

SHIPBUILDING

665,392. April 20, 1949.—Securing Means for Inlet Covers for Ships' Hulls, William Moodie Thomson, of "Glenburn," Meilke Avenue, Renfrew, Renfrewshire.

The object of this invention is to make provision for securing cover plates or other attachments to a ship's shell so that they can be detached by a worker in the interior of the hull and will drop off. In the upper drawing the inner screw part shown consists of a screwed stud with a square head *A* and a ridge-like key *B* across the other end. A portion of a ship's shell plating *C*, a portion of a cover plate *D* and intervening joint material *E* is also shown. A number of bosses are secured to the shell at appropriate intervals around the inlet opening to be covered by the plate, one of these being shown as a small, but thick, plate *F* welded to the inner surface of the shell. A hole is drilled through each thick plate and the shell plating and is tapped to form a continuous thread. The two-part screws *G* and *H* are driven from inside the hull until each, as shown, comes about flush with the outer surface of the cover plate. The two parts of each screw are arranged end to end with the keyed end *B* mating with the slotted end of *H*. An annular gap is left between the screw threadings at the abutting ends of the screw parts. As the lower view shows, when it is desired to release the cover plate *D* so



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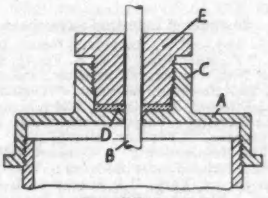
that it can drop off, each of the studs *G* is turned sufficiently to drive the associated grub screw out of the tapped hole in the shell.—*January* 23, 1952.

SHAFT PACKINGS AND GUIDES

665,487. May 6, 1949.—Fluid Sealing Glands, Gaskell and Chambers, Ltd., of Dalex Works, Coleshill Street, Birmingham, 4 (*Inventor: James Garrick Sutherland Ironside*).

As shown in the drawing, the cylinder end cover *A*, through which a pump piston rod *B* extends, is



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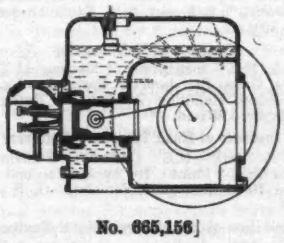
formed with a hollow and internally screw-threaded boss *C*, the base of which provides a flat seating for an annular sealing washer *D* of rubber, leather, or any other appropriate flexible material. The outer edge of the hole in the seating is bevelled, or recessed. A gland nut *E* presses the washer tightly on to the seating. When pushed on to the rod a portion of the washer around its hole is deformed, causing a thin lip to extend from one side. The bevelling of the outer edge of the hole in the seating is such as to accommodate the lip and enable the pressure of the liquid passing through the clearance between the seating and the rod from the pump cylinder to act on the lip. The specification also shows a modified construction with the flexible washer between two metal washers.—*January* 23, 1952.

INTERNAL COMBUSTION ENGINES

665,156. March 31, 1949.—Cooling of Horizontal Internal Combustion Engines, Hans List, 126, Heinrichstrasse, Graz, Austria.

As the drawing shows, the cooling water space extends over the entire length of the crankcase, so that the upper wall and the crankcase, as well as the cylinder wall and the parts of the crankcase adjoining the cylinder wall, are in direct contact with and cooled by the water. By this arrangement



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an increase of the cooling water surface is obtained and the crankcase wall is also cooled. These results are attained without the water space having to be extended laterally beyond the crank casing. The flywheel is arranged adjacent to the casing enclosing the cooling water space, and parts of the engine casing which are exposed to the air current produced by the flywheel are provided with cooling ribs.—*January* 16, 1952.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., Feb. 25th.—BOURNEMOUTH BRANCH: Grand Hotel, Firvale Road, Bournemouth, "Germanium Crystals," S. A. Bell, 7.30 p.m.

Illuminating Engineering Society

Mon., Feb. 25th.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, "Electric Lighting: A Contractor's Viewpoint," J. Ashmore, 7 p.m.

Incorporated Plant Engineers

Mon., Feb. 25th.—W. AND E. YORKS BRANCH: The University, Leeds, "Further Advances in Metallurgy," Dr. Irvine, 7.30 p.m.

Tues., Feb. 26th.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Modern Practice in the Welding of Pipes," E. Fuchs, 7 p.m.

Fri., Feb. 29th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Costing and the Plant Engineer," E. E. Mitchell, 7.30 p.m.

Institute of British Foundrymen

Sat., Feb. 23rd.—BRISTOL AND WEST OF ENGLAND BRANCH: Grand Hotel, Broad Street, Bristol, "Recent Developments in Magnesium," J. Sully, 3 p.m.

Wed., Feb. 27th.—LONDON BRANCH: Waldorf Hotel, Aldwych, W.C.2, "Investment Casting," G. A. Tomkinson, 7.30 p.m.——BIRMINGHAM BRANCH: Grand Hotel, Birmingham, "Experiences with the Investment Casting Process," D. F. B. Tedds, 7.15 p.m.

Institute of Industrial Administration

Tues., Feb. 26th.—Management House, Hill Street, London, W.1, Symposium on "Works Management," 7 p.m.

Institute of Industrial Supervisers

Mon., Feb. 25th.—N.W. SECTION.: Grand Hotel, Manchester, "Foremanship," T. E. A. Verity, 6.30 p.m.

Tues., Feb. 26th.—LEICESTER SECTION: College of Technology, The Newarke, Leicester, "Time Study: Its Use and Effects," J. A. Cullin, 7.30 p.m.——KIDDERMINSTER SECTION: Carpet Trades, Ltd., Mill Street, Kidderminster, "Factory Morale and Discipline Under Full Employment," L. Leonard, 7.30 p.m.

Thurs., Feb. 28th.—LEEDS SECTION: Windmill Hotel, Blossom Street, York, "A Survey of Industry," A. Mehrtens, 7.30 p.m.——SMETHWICK SECTION: Chance Technical College, Crocketts Lane, Smethwick, "American Foremanship Report," W. J. Izzard 7.30 p.m.——GLASGOW SECTION: Royal Technical College, Glasgow, Joint Meeting and Discussion with Glasgow Branch, Institution of Works Managers, 7.30 p.m.——ROTHERHAM SECTION: Technical College, Rotherham, "Factories Acts and Safety," E. W. Huddy, 7.30 p.m.

Fri., Feb. 29th.—N.W. SECTION: Unity Hall, Greek Street, Stockport, "Motion Study on the Shop Floor," N. G. Moss, 8 p.m.

Institute of Marine Engineers

Wed., Feb. 27th.—King's College, Strand, London, W.C.2, "Marine Diesel Engines," C. C. Pounder, 5.30 p.m.

Thurs., Feb. 28th.—Wandsworth Technical College, Wandsworth High Street, S.W.18, "Marine Diesel Engines," C. C. Pounder, 7 p.m.

Institute of Metals

Thurs. Feb. 28th.—BIRMINGHAM LOCAL SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Metallurgical Research in the U.S.A.," C. S. Barrett, 7 p.m.

Fri., Feb. 29th.—BIRMINGHAM LOCAL SECTION: College of Technology, Birmingham, All-Day Symposium on "New Techniques of Metallurgical Research," Opening Address by A. G. Quarrell, 10.30 a.m.

Institute of Navigation

To-day, Feb. 22nd.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Navigation Aids for Military Aircraft," D. Bower, 5 p.m.

Institute of Petroleum

Mon., Feb. 25th.—26, Portland Place, London, W.1, "Air and Vapour Release from Aviation Fuels," L. D. Derry, E. B. Evans, B. A. Faulkner and E. C. G. Jelfs, 5.30 p.m.

Institute of Refrigeration

Tues., Feb. 26th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, "Mechanical Handling Applied to Refrigeration," L. R. Meyer, 5.30 p.m.

Institute of Road Transport Engineers

Tues., Feb. 26th.—N.E. CENTRE: Dunelm Hotel, Durham City, "Paint: Its Application and Maintenance on Road Transport Vehicles," G. S. Metcalfe, 7 p.m.

Institution of British Agricultural Engineers

Tues, Feb. 26th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Four-Wheel Drive Tractors," G. R. G. Gates. 2.15 p.m.

Institution of Chemical Engineers

To-day, Feb. 22nd.—LONDON CENTRE, GRADUATES' AND STUDENTS' SECTION: Caxton Hall, Westminster, S.W.1, "A Small General Purpose Plant for Pharmaceutical Development," V. C. Salvage, 6.30 p.m.

Fri., Feb. 29th.—N.E. CENTRE, GRADUATES' AND STUDENTS' SECTION: Stephenson Building, Claremont Road, Newcastle on Tyne, "The Place of Instrumentation in Chemical Plant," A. H. Isaac, 6.15 p.m.

Institution of Civil Engineers

Tues., Feb. 26th.—Great George Street, Westminster, London, S.W.1, "The Influence of Multiple-Wheel Undercarriages on the Design and Evaluation of Airfield Pavements," G. S. Cooper, 5.30 p.m.

Thurs., Feb. 28th.—Great George Street, Westminster, London, S.W.1, Discussion "Relative Economics of Prestressed Concrete Compared with Reinforced Concrete, Steel and Other Forms of Construction," 5.30 p.m.

Fri., Feb. 29th.—YORKSHIRE ASSOCIATION: Electricity Showroom, Hull, "Tunnelling Plant and Equipment," G. P. Archer, 6.15 p.m.

Institution of Electrical Engineers

To-day, Feb. 22nd.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Engineering Graduation Theses at the University of Cape Town," opened by B. L. Goodlet, 6 p.m.

Mon., Feb. 25th.—RADIO SECTION: Savoy Place, London, W.C.2, Debate "In the Opinion of this House, the Lone Worker Can No Longer Make a Major Contribution to Radio Development," 5.30 p.m.

Tues., Feb. 26th.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Inductor Compass," A. Hine, 7 p.m.

Wed., Feb. 27th.—SUPPLY SECTION: Savoy Place, London, W.C.2, "Performance of Natural Draught Water Cooling Towers," H. Chilton, 5.30 p.m.——S. MIDLAND STUDENTS' SECTION: G.E.C. Telephone Works, Coventry, "Telecommunications in the Midlands," W. H. Brent, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tues., Feb. 26th.—39, Elmbank Crescent, Glasgow, "On the Acceleration of Ships," H. Lackenby, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Feb. 22nd.—Storey's Gate, St. James's Park, London, S.W.1, "Factors Affecting the Utilisation of Anti-Knock Quality in Automobile Engines," J. D. Davis; "Recent Developments in 'Knock' Research," D. Downs and R. W. Wheeler; "The Significance of Laboratory Octane Numbers in Relation to Road Anti-Knock Performance," H. J. Eatwell and J. G. Withers: two sessions, 4 p.m. and 5.30 p.m.

Tues., Feb. 26th.—N.W. BRANCH, GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, "An Approach to Manufacturing Cost Reduction," C. H. Radforth, 6.45 p.m.——BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "Experiences During Twenty Years of Oil Engine Development," C. B. Dicksee, 6.45 p.m.

Wed., Feb. 27th.—WESTERN BRANCH, GRADUATES' SECTION: College of Technology, Unity Street, Bristol, "Three Post-War Testing Machines of Especial Interest to the Aircraft Industry," R. Hardy, 7 p.m.——YORKSHIRE BRANCH: The University, Sheffield, "The Principles of Continuous Gauge Control in Sheet and Strip Rolling," W. C. F. Hessenberg and R. B. Sims, 7 p.m.——N.W., A.D. CENTRE: Engineers' Club, Albert Square Manchester, Annual General Meeting, 7.15 p.m.

Thurs., Feb. 28th.—WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Brake Linings," J. G. Remington, 6.45 p.m.

Fri., Feb. 29th.—Storey's Gate, St. James's Park, London, S.W.1, "Gear Tooth Stresses and Rating Formulæ," H. E. Merritt, 5.30 p.m.——E. MIDLAND BRANCH, GRADUATES' SECTION: Technical College, Lincoln, Short Papers and Discussion Evening, 7.15 p.m.

Institution of Post Office Electrical Engineers

Wed., Feb. 27th.—Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "Television Interference," J. S. Hizzey and J. R. Turner, 5 p.m.

Institution of Production Engineers

Tues., Feb. 26th.—LONDON GRADUATE SECTION: 36, Portman Square, W.1, "How the Money Moves in Business," T. G. Rose, 7.15 p.m.——LUTON SECTION: Town Hall, Luton, "Drop Forging," J. C. Sharman, 7.15 p.m.——LUTON GRADUATE SECTION: W. H. Allen and Co., Ltd., Queen's Engineering Works, Bedford, "Design is more Important than Production," Debate, 7.30 p.m.

Wed., Feb. 27th.—SHREWSBURY SECTION: Walker Technical College, Oakengates, Salop, "Pattern for Progress: Production of Steel, Sheet and Tin Plate," A. S. Huxley, 7.30 p.m.

Thurs., Feb. 28th.—CORNWALL SECTION: Technical College, Trevenson Park, Pool, "An Assessment of Production Engineering Training," T. B. Worth, 7.15 p.m.——LONDON SECTION: Creed and Co., Telegraph House, Colston Road Entrance, Near East Croydon Station, Croydon, Surrey, "Modern Electroplating and Metal Finishing Processes," H. Cann, 7 p.m.——S. WALES AND MONMOUTHSHIRE SECTION: S. Wales Institute of Engineers, Park Place, Cardiff, "The Manufacture of Ball and Roller Bearings," R. K. Allan, 6.45 p.m.

Fri., Feb. 29th.—N.E. GRADUATE SECTION: N. of England Institute of Mining and Mechanical Engineers, Neville Hall, Newcastle upon Tyne, "Presswork," J. M. Phillips, 7 p.m.

Institution of Structural Engineers

Thurs., Feb. 28th.—11, Upper Belgrave Street, London, S.W.1, "The Torsional Strength of Structural Members," W. B. Dobie, 5.55 p.m.

Junior Institution of Engineers

To-day, Feb. 22nd.—39, Victoria Street, London, S.W.1, "The Lessons of the Anglo-American Productivity Reports," R. G. Hooker, 6.30 p.m.

Fri., Feb. 29th.—39, Victoria Street, London, S.W.1, "Concrete: Use and Abuse," A. E. Taigel, 5.30 p.m.

Liverpool Engineering Society

Wed., Feb. 27th.—24, Dale Street, Liverpool, "Some Aspects of Refrigeration Practice," J. Douglas, 6 p.m.

Manchester Association of Engineers

To-day, Feb. 22nd.—Engineers' Club, Albert Square, Manchester, "Prestressed Concrete," G. B. Tait, 6.45 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Feb. 22nd.—Mining Institute, Newcastle upon Tyne, "Aluminium Alloys as Shipbuilding Materials," E. C. B. Corlett, 6.15 p.m.

Royal Aeronautical Society

Tues., Feb. 26th.—GRADUATES' AND STUDENTS' SECTION: 4, Hamilton Place, London, W.1, "Meteorology from the Pilot's Point of View," L. Welch; "Gravity as an Aid to Soaring," R. C. Scorer, 7.30 p.m.

Society of Instrument Technology

Tues., Feb. 26th.—Royal Society of Hygiene and Tropical Medicine, Manson House, Portland Place, London, W.1, "Temperature Pocket Lags," W. Fishwick, 6.30 p.m.

Woolwich Polytechnic

Wed., Feb. 27th.—Woolwich Polytechnic, London, S.E.18, "Education for Management in U.S.A. and England," Sir Thomas Hutton and J. Wilson, 7 p.m.

Codes of Practice

The Council for Codes of Practice for Buildings—Construction and Engineering Services, is under the aegis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

EARTH RETAINING STRUCTURES

This code has been issued by the Institution of Structural Engineers on behalf of the Civil Engineering Codes of Practice Joint Committee of the Institutions of Civil, Municipal, Water and Structural Engineers. It deals with the design, construction and maintenance of all types of structures required to retain soils at a slope steeper than that which they would naturally assume, or to protect soil banks from destructive agencies. The design of such a structure is taken to include all things needful to make it fulfil its purpose, i.e., to ensure that it shall be strong, stable, durable, economical in first cost and maintenance and pleasing in appearance. The code is applicable to structures retaining materials other than soils provided their relevant characteristics can be ascertained, but it does not deal with structures for retaining liquids. The first chapter of the code deals with such general matters as the estimation of forces, the various kinds of structure and the reason for their choice. Subsequent chapters deal with gravity walls, reinforced concrete walls, sheet pile walls, cribwork, revetments and walls subject to wave action, and describe the materials used and special points affecting the design and construction of each kind. The appendices include definitions of the terms used, a list of symbols, a list of matters requiring site investigation, some worked examples, examples of wall failures and a bibliography. Price 15s.

Launches and Trial Trips

BRITISH SKILL, oil tanker; built by Harland and Wolff, Ltd., for the British Tanker Company, Ltd.; length between perpendiculars 610ft, breadth moulded 81ft, depth moulded 44ft 6in, deadweight 28,500 tons; single set of compound, double-reduction geared turbines of 12,500 service s.h.p., at a propeller speed of 112 r.p.m.; two oil-fired Babcock and Wilcox water-tube boilers supply steam at 450 lb per square inch and 750 deg. Fah.; two B.T.H. 600kW turbo-alternators. Launch, January 16th.

BILL, motor tanker; built by the Netherlands Dock and Shipbuilding Company, Amsterdam, for A.S. Bill (L. Gill Johannessen), Oslo; length between perpendiculars 532ft 6in, moulded breadth 72ft 9in, depth 38ft 3in, deadweight 18,500 tons on 29ft 6in draught; Stork diesel engine, seven cylinders, 7500 b.h.p. at 118 r.p.m., trial speed 15¼ knots. Launch, January 26th.

FLOWERGATE, cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Turnbull Scott Shipping Company, Ltd.; length overall 441ft 3in, breadth 56ft 8in, depth moulded to shelter deck 38ft 3in, deadweight 9400 tons, draught loaded 25ft 10in; Kincaid-Harland and Wolff-Burmeister and Wain two-cycle, single-acting diesel engine, four cylinders, 620mm diameter by 1870mm combined stroke, 3300 b.h.p. at 125 r.p.m. Launch, January 28th.

ENTON, cargo liner; built by Alexander Stephen and Sons, Ltd., for Birt, Potter and Hughes; length 432ft, breadth 58ft 9in, depth 39ft 6in, deadweight 9900 tons, draught loaded 27ft 2in; Stephen-Doxford oil engine, five cylinders, 670mm diameter by 2320mm combined stroke, 5500 b.h.p. at 115 r.p.m., sea speed 14 knots. Launch, January 29th.

M.S.C. "QUEST," tug; built by Henry Robb, Ltd., for the Manchester Ship Canal Company; length overall 95ft, breadth moulded 24ft, depth moulded 12ft; two Crossley diesel engines, four cylinders, 1200 total b.h.p. at 250 r.p.m. Launch, January 29th.